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PRINCIPLES GOVERNING THE VALUE OF HERBAGE PLANTS FOR HAY AND PASTURE USE*

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[Translator: G. M. ROSEVEARE]

THE general intensification of grassland farming through the modern practice of using the same land for haying and grazing suggests the desirability of enquiring into the principles which govern the value of herbage plants for hay and pasture use respectively.

It is well known that the practices of mowing and grazing respectively have a severely selective effect upon natural plant stands, and are, at all events for the greater part of central Europe, responsible for the evolution of hay land and grazing land. They result in the disappearance of a large number of plants, and in the particularly good development of others.

The mowing of a meadow once a year only is sufficient to remove all woody plants, obviously because their assimilation and storage of reserves are stopped. If mowing is extended from once to twice a year, there disappear, in addition to many herbs, some grasses with poor regenerative capacity such as *Molinia coerulea*. With the taking of three or four cuts a year many very productive grasses such as *Avena elatior* are destroyed. Although moderate grazing is similar to mowing in its action, yet frequent grazing produces entirely different effects, partly through the cropping and treading of the animals, but partly also through the definite sparing of certain plants. Under favourable conditions and with optimal stocking (number of animals per unit area) a pasture may approach very closely to the ideal of what grassland should be, that is to say, a sward almost entirely composed of highly regenerative and valuable fodder plants. If, however, frequency of grazing and density of stocking are carried too far and at the same time manuring is neglected, peculiar types of sward arise. The valuable grasses and legumes either disappear or assume such a dwarf habit that it is scarcely possible for animals to crop them. Their place is taken by plants which animals will graze only to a limited extent or not at all, namely,

*Translation of paper presented in German to the Fourth International Grassland Congress, Aberystwyth, July, 1937.

poisonous plants, plants of flat, rosette habit, and reeds, rushes, and undershrubs. The final result of over-grazing is to be seen in our dwarf-shrub heaths (*Calluna, Genista, Sarothamnus, Ononis, Rosa, Prunus spinosa, Juniperus*). It would almost appear as if a natural law were here in action, according to which plants rarely possess more than one kind of protective apparatus. Either they have a direct means of protection from grazing such as poisonous principles, spines, or lignification—and then as a rule they have little capacity for regeneration ; they are, it is true, avoided by animals, but it is generally easy to destroy them by mowing or hoeing. Or else they have very great regenerative capacity, in which case they lack poisons, spines and lignification. They are encouraged, up to a point varying in accordance with the species concerned, by mowing and grazing, but when these are carried too far they become exhausted, and there now appear either bare patches or swards of such plants as have nothing to fear from cutting and grazing, that is to say, low-growing rosette plants, mosses and lichens.

Within these extremes—mowing or grazing too seldom on the one hand, too much on the other—are to be found the different forms of successful grassland management ; only in the mountains do the above-mentioned extremes still play an important part.

Even within the limits of normal management, however, (two or three hay cuts in the year, modern rotational grazing), there are exhibited far-reaching differences in the effect of mowing and grazing respectively upon yield, botanical composition and manurial requirements—to mention a few only of the results of utilization.

In order to obtain a general picture of specific behaviour, we have summarized frequency and dominance as found in 1,200 analyses of German swards. Certain figures for the products of mean frequency and dominance were thus obtained, which enable comparisons to be made on the behaviour of a species in relation to mowing and grazing.

The following facts have thereby come to light :

(1) In two-cut meadows many more species attain a position of equal importance (frequency and dominance) than in pastures, where the more severely selective action of grazing finds expression.

(2) Between the extremes represented in the hay types discouraged by grazing and the extreme pasture type of grass, there are species whose incidence is but little affected by the form of utilization.

The ratio of frequency and dominance in meadows to that in pastures is, for example.

	Meadow : Pasture
in *Lathyrus pratensis*	622 : 1
Avena elatior	106 : 1
Phalaris arundinacea	30 : 1
Alopecurus pratensis	22 : 1

Similar behaviour is seen in *Vicia sepium* (675 : 1), *Vicia cracca* (79 : 1), *Avena flavescens* (56 : 1), *Trifolium pratense* (23 : 1) and numerous other species. These, then, are species very sensitive to grazing, and this sensitivity is often carried to an unexpectedly high degree.

On the other hand in the following species the ratio of frequency and dominance in pastures to that in meadow is :

	Pasture : Meadow
in *Lolium perenne*	33 : 1
Cynosurus cristatus	6 : 1
Trifolium repens	5 : 1
Poa pratensis	4 : 1

In *Phleum pratense* (4 : 1), *Agrostis alba* (3 : 1), and a few other species only, similar behaviour is found. These are thus good pasture species ; their number is much lower than that of the species sensitive to grazing ; they have little to suffer from competition when grazed and thus occasionally reach extraordinarily high degrees of frequency. While the mean proportion of the sward occupied by the following pasture plants is :

	Per cent
Lolium perenne	23.2
Poa pratensis	13.8
Trifolium repens	10.6

in the principal hay plants it is only

	Per cent
Alopecurus pratensis	6.2
Avena flavescens	4.4
Trifolium pratense	3.4
Avena elatior	2.9

The ten principal species of permanent pastures form on an average 82 per cent of the sward, the ten principal meadow species only 41 per cent ; and while only eleven species are found in an average proportion of more than 1 per cent in pastures, in meadows there are twice as many herbage plants and a large number of weeds in addition. The principal components of meadow yield recede in pastures ; the principal pasture plants play only a mediocre part in the meadow, or none at all.

Between these two extremes stand those species which thrive equally well under mowing and grazing, for example, *Dactylis glomerata*, *Festuca pratensis*, *Festuca rubra*, *Poa trivialis*, with a ratio of meadow to pasture incidence that varies little from 1 : 1.

Very different and by no means always explicable causes determine this fundamentally, and in some cases extremely discrepant behaviour in the various species. We will attempt to discover in some typical cases what these causes are.

An example of the most extreme type is *Molinia coerulea*, which cannot bear regular mowing even to the extent of only two cuts annually. As has been shown by Stebler and Schröter, the storage of reserves in this grass does not begin until late in the autumn ; cutting before the reserve substances have been conducted back into the internode results in a weakening of the plant to the point of gradual extinction.

Species of the second type such as *Avena elatior*, *Phalaris arundinacea*, *Medicago sativa varia*, thrive best under a two, three or four cut system, in accordance with circumstances. In the case of these plants it is principally a giving-out of nutrients that takes place during the first weeks of growth, and they therefore suffer very considerably under frequent early mowing. But very soon, even while vigourous growth is taking place, there begins a migration of assimilates back to special reserve organs or to protected parts of the root or the tillering zone. Thus, in accordance with the particular species, several cuts during or shortly before the beginning of flowering are readily borne. In the case of lucerne we are able to make a fairly accurate estimate of the number of days' growth or (according to Meijers) of the amount of warmth requisite for the storage of reserves ; in the case of the other species we hope soon to reach this stage. When these requisite periods of growth are respected the species mentioned will tolerate careful grazing very well unless their tillers or rhizomes are especially sensitive to trampling. On the other hand, all these species, and unfortunately many meadow legumes also, disappear under continuous close cropping.

The species named are characterized by preponderantly tall, erect shoots, by only a slight formation or even an absence of basal leaves, and generally also by complete winter rest. Mowing and grazing almost entirely destroy the assimilating bulk.

The following type, which is neither injured nor encouraged to any great extent by mowing and grazing, exhibits a greater preponderance of basal leaves, that is to say, short leaf shoots as opposed to haulm shoots. *Dactylis glomerata* and *Festuca pratensis* are more or less characteristic. *Dactylis* nevertheless exhibits a certain sensitivity to frequent utilization in the early stages ; in our experiments the taking of four cuts reduced the subterranean bulk 23 per cent more than three cuts. But similar injury was produced by the taking of three cuts at a very early stage, while optimum yield was obtained from taking three to four cuts as late as possible, wherein, however, all leaf bulk capable of assimilation was carefully removed. In the open, *Dactylis* is generally able to retain a large number of effective leaf fragments even when severely mown and grazed, especially as in pastures it is rarely entirely cropped. *Festuca pratensis* is not only green and capable of assimilation for a particularly long time, but the direction of the shoots and the accumulation of the leaves at the base of the shoot always ensure that an abundance of leaf parts remains even when it is mown or grazed close to the ground. At the same time this species also is not altogether encouraged by very frequent use.

This is, however, the case where the definite pasture type is concerned, represented by, for example, *Lolium perenne*, *Trifolium repens* and *Poa pratensis*. It is

certain that the encouraging action of grazing is based not only on protection from shading, but also on the frequent utilization. Even when these species are planted out singly and there is thus no question of shading, persistence and capacity for spreading are discouraged rather than promoted through rarely using them and through allowing them to flower. These and other species—under properly regulated conditions of frequent grazing—cannot be so closely cropped as to be unable to reform an adequate amount of leaf bulk capable of assimilation. In addition they are often characterized by a particularly long growth period, sometimes extending throughout the winter. The very thing which is a life necessity for *Avena elatior* and *Medicago sativa*, namely, a long period of undisturbed growth of fertile tillers or flower shoots, is undesirable in the case of the pasture type. In this type, flowering seems to interrupt assimilation and storage to an injurious extent, but continuous forcing to fresh tillering appears to promote them.

The most extreme example of this last type, or at all events of a similar one, is probably *Cirsium arvense*, the rhythm of assimilation and storage in which has been revealed through the research of the last decade. Repeated removal of the leaf rosettes does not injure them at all, as they are obviously able to store enough assimilates even when their life span is short ; but during the structure of the flowering stem the giving out of nutrient matter preponderates so greatly that *Cirsium* is destroyed when mown two or three times at the flowering stage. The dying back of the thistle in correctly utilized lucerne and the flourishing of the thistle in misused lucerne disclose a complete antagonism. The same thing is seen in the disappearance of *Lolium* mown two or three times only, even when there is little competition, and in the disappearance of *Avena elatior* in a *Lolium* sward grazed six to eight times.

In this connexion we have made a close comparison of *Poa pratensis*, *Dactylis glomerata* and *Medicago varia*. It was first noted that the parts of the plants which were not green, namely, the tiller zone and roots (as far as attainable), amounted to the following percentage of the green weight (all calculated on the dry matter, mean of ten cuts) :

	Mean percentage
in *Poa*	134.6
,, *Dactylis*	94.1
,, *Medicago*	30.5

Poa has an extensive, *Medicago* a very insignificant storage apparatus. During the early stages of development in particular, the accumulation of nutrients in the subterranean organs of *Poa* exceeds the formation of aerial matter by 80 to 90 per cent, while in *Medicago* it falls behind to an equal extent. *Dactylis* always occupies an intermediate position.

When varying numbers of cuts were taken, it was next seen that four cuts, as opposed to two cuts, resulted in the following diminution of yield :

Poa	by 6 per cent
Dactylis	,, 19 ,, ,,
Medicago	,, 56 ,, ,,

that is to say, *Poa* is practically uninjured, but *Medicago* very severely injured by frequent mowing. (In the locality in which the experiments were made, optimal results are obtained by cutting lucerne two to three times ; under other circumstances the reduction described above would not occur until five cuts had been taken.)

At the same time the proportion of tiller and root capable of storage was reduced after four cuts (as opposed to two).

in *Poa*	by 32 per cent
,, *Dactylis*	,, 40 ,, ,,
,, *Medicago*	,, 53 ,, ,,

All this makes it relatively easy to recognize the characteristic differences in the types described. It holds good not only for the dry weight, but also—sometimes to a still greater extent—for the stored nutrients.

It is true that things cannot be the same everywhere, but on the whole the following are probably of decisive importance :

(1) general rate of growth ;
(2) rhythm of assimilation and storage (definite alternation or concurrence) ;
(3) principal zone of assimilation and storage (haulm leaves, long shoots, short shoots, storage in the tiller zone, in rhizomes or roots).

In addition to the above, of course, competition also plays a certain part, but rarely a decisive one ; the direct effects of wounding, soil consolidation, etc. must also be considered.

In one respect frequent mowing and frequent grazing appear to work in the same direction, namely, in the reduction of root bulk and rooting depth. (Recent root studies by Witte, Kauter and others show that the deep-rooting grasses are especially sensitive to grazing, and that the pasture plants are in general more shallow-rooting than the definite hay plants). This explains not only the necessity for better supplies of water and fertilizers when there is frequent mowing or grazing, but also their relatively better effect. We found, for example, the following increase in the yield of similarly manured swards as opposed to no-manure plots (*Avena elatior-Dactylis*, mean of five years).

with	two	cuts	52 per cent
,,	three	,,	61 ,, ,,
,,	four	,,	96 ,, ,,

These are relative increases in yield, for the absolute bulk yields are not by any means always increased under frequent cutting and permanent grazing. Disastrous as is on the one hand over-grazing in conjunction with deficient plant nutrition, just as great possibilities are opened up on the other through purposeful manurial treatment and watering. There is no kind of culture which will respond so profitably to the continuous application of heavy doses of manure as frequently utilized grassland. The highest level of nutrition is a necessity, because the root system of the herbage loses contact with the lower soil strata alike under very frequent mowing and under permanent grazing.

In other respects, however, frequent mowing and frequent grazing produce very different results. Species which tolerate grazing six to eight times are often detrimentally affected by three or four cuts only.

This surprising degree of difference is frequently attributed to the exercising of a specifically favourable action in the bite and tread of the animals, to cropping as opposed to cutting, and to consolidation of the soil. It is impossible to explain so fundamental a difference in this manner.

We consider its causes to lie rather in the entirely different effects of the scythe and the grazing animal respectively upon the assimilating leaf mass and upon the storage of reserves.

Scythe and mowing machine leave the ground practically bare ; after harvest, especially in the case of the looser swards composed of tall plants, there remains very little assimilating leaf bulk. Interruption of the formation of substance thus produced goes hand in hand with a weakening of performance in the subterranean organs, the reserves of which are drawn upon for the formation of a new leaf apparatus. The more frequently cutting takes place, the more unfavourably must the effect of these disadvantages be reflected in yield and in the vigour of the after-growth.

Quite different is the state of affairs in a close and properly stocked pasture sward. Its assimilating leaf bulk, to be sure, is also greatly reduced under grazing, but considerably more slowly and never so completely as under mowing. The area remains green, the grass leaves continue to assimilate.

In these differences between the effect of mowing and grazing lies the source of great progress, which may be achieved through a scientific alternation of the two forms of utilization.

We are, however, still far from obtaining a real mastery of the fodder production problem. Although we know the optimal kind and form of utilization for one or two meadow and pasture types, we do not by any means know them for all. Least of all have we definite information in regard to the individual plants ; even in the case of important plants such as lucerne grave mistakes in utilization are made by growers, and only the special research of the last few years holds out a prospect of improvement here. When the same number of cuts are taken, weed growth may vary from 5 to 70 per cent in accordance with the time of cutting, and yield may be very great or very small. But I anticipate still more important results from a closer study of these matters as applied to pastures and mown pastures. Here in particular the utilization of the sward in the seeding year, the influencing of the proportions of species in mixtures, weed control, the time at which fertilizers and rainfall should be employed and the question of quantity in connexion therewith, all these furnish many fruitful subjects for a form of research which may be described as the applied science of life forms.

THE BREEDING OF SWEET LUPINS

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[Translator : G. M. ROSEVEARE]

LUPINS have been under cultivation for approximately a thousand years. Up to the previous century the form most frequently grown was as a rule the white lupin (*Lupinus albus*), which is distributed about the shores of the Mediterranean. The plants were used as green manure, and also for human and animal consumption when the bitter principle had been removed by soaking in water.

The white lupin, in spite of its good properties, was not able to gain a foothold in Germany and neighbouring regions such as Poland. Here, in the middle of the nineteenth century, two other species of lupin spread rapidly : *Lupinus luteus* and *Lupinus angustifolius*. These also were used as green manure and, when disembittered, as a feeding stuff.

The value of the lupin lies in its high protein content (30 to 40 per cent), which is equalled in few other crop plants. Its principal disadvantage, the high alkaloid content which made the disembitterment process necessary, has always been troublesome, but accepted as inevitable. Only to sheep could lupins be fed without previous treatment.

At the end of the nineteenth century a new animal disease, named "lupinose," made its appearance in consequence of feeding the grain and straw of yellow and blue lupins to stock. The disease assumed such proportions that considerable limits were set to the cultivation of lupins. Although an intensive study of the disease was made, neither the causal agent nor the actual cause could be determined.

The cause of the lupin's characteristic bitter taste is to be found in the alkaloids. A desire to obtain lupins having a low alkaloid content, or being entirely alkaloid-free, has always been felt.

At the beginning of the present century the alkaloid problem was attacked again and again by a series of workers. It was Roemer in particular who made a study of differences in this respect and who sought for forms with low alkaloid content. In 1924, Prjanišnikov attempted to evolve a chemical method of making tests, and expressed the conviction that it would be possible to detect alkaloid-deficient forms if the number of plants tested was sufficiently large. Baur expressed similar beliefs in 1927. In the course of a lecture he asserted that alkaloid-deficient forms must exist among the ordinary bitter lupins of the present day. It was only a matter of discovering the right method of detecting them. He assumed that the peas (*Pisum sativum*) now in use, which have no bitter taste, possibly emanated from bitter forms.

In 1927 I began to work out a technique for the detection of alkaloid-deficient forms. In the first experiments biological methods were employed, with a view to utilizing the poisonous action of the alkaloids. These methods were not successful.

Next I succeeded in working out a chemical method which appeared to be suitable for dealing with a large amount of material. At the outset it was not known whether entirely alkaloid-free types actually existed. For this reason search was first made for individuals with an alkaloid content reduced by 20 per cent. When these plants had been detected, forms with an alkaloid content lower by 50, 70, 90 per cent and over, became the objective, and such plants also were found.

From some varieties of lupin species I then selected, during the years 1927 to 1931, forms practically free of alkaloids. In order to detect the few alkaloid-free individuals I have studied a total of many million single plants. These individuals have been reproduced throughout the past ten years. Since 1931 reproduction has been in the hands of the Saatgut-Erzeugungs-Gesellschaft (Seed Production Company), Berlin, which not only reproduces the sweet lupins but is also engaged in further breeding work with them. The following varieties are to-day in the market: yellow von Sengbusch's Müncheberg green fodder sweet lupin, and blue von Sengbusch's Müncheberg green fodder sweet lupin.* The white sweet lupin is not yet released for sale.

Such progress has been made with the reproduction of sweet lupins that to-day not only can requirements in Germany be covered, but in other countries also, and in Poland in particular, sweet lupins are being reproduced for sale.

More recently other workers have found alkaloid-free yellow, blue, white and perennial lupins by means of a biochemical method (Laube, Heuser; Ivanov, Smirnova, Fedotov, *Herb. Abstr.* 3. 48. 1933.)

In addition to this most important problem in the breeding of lupins, the discovery of alkaloid-free forms, there were others to be solved.

(1) The elimination of hardness of seed-coat in *Lupinus luteus* and *Lupinus angustifolius*. By suitable drying, together with examinations for softness of seed coat, we succeeded in selecting individuals having entirely soft-coated seeds. For the discovery of these forms approximately 20,000 single plants were studied.

(2) Of the utmost importance also is the elimination of the tendency of the pods to shatter, both in *Lupinus luteus* and *Lupinus angustifolius*. In warm harvest weather the shattering of pods may cause a loss of 50 per cent and over. Normally the loss amounts to 20 per cent.

I started the selection of non-shattering forms in 1929. Although I examined several million single plants, efforts were at first unsuccessful. Not until 1935 and 1936 was an individual found possessing completely indehiscent pods (von Sengbusch and Zimmermann). In 1936 and 1937 the descendants likewise proved to have non-shattering pods. We have been able to ascertain that in this strain the character "non-shattering" is based upon the abnormal structure of the pod suture. The sclerenchyma strands, which in normal lupins are separate, are united in the non-shattering form and thus prevent the splitting of the sutures.

We studied altogether considerably over ten million plants before this strain, No. 3535A, was found.

*" Gelbe von Sengbuschs Müncheberger Grünfutter Süsslupine " and " Blaue von Sengbuschs Müncheberger Grünfutter Süsslupine " are the legally protected names of the varieties.

These valuable characters, namely, freedom from alkaloids, soft seed coat, and indehiscent pods, were sought separately ; that is to say, in each case plants with one or other of these characters were selected out of indigenous bitter material. Our task now is to combine these characters with one another, to produce a plant which shall be alkaloid-free and shall have soft seed-coats and non-shattering pods.

In order to ascertain what combinations are possible, inheritance in the separate characters was studied. We were able to prove that all three characters are each based upon a recessive factor, and that there thus exists a very good possibility of combining them rapidly. The freedom from alkaloids in the respective strains rests upon different genes. In the crossing of two strains which are alkaloid-free on the basis of the different genes, the F_1 generation contains alkaloids, the F_2 generation segregates into a ratio of 9 alkaloid-containing : 7 alkaloid-free individuals. One of these sixteen combinations contains both genes for freedom from alkaloids. When crossed with either parent, it gives alkaloid-free forms. These doubly recessive alkaloid-free strains may under certain circumstances be of practical importance. Their alkaloid content might be still farther reduced in comparison with the initial alkaloid-deficient forms. Work on the production of these forms is in progress.

Within another ten years we shall be able to grow an ideal form of the lupin, alkaloid-free, having soft seed-coats and indehiscent pods. For the agriculture of Germany, and of the surrounding countries with similar climatic and soil conditions, the new sweet lupins are a valuable addition to the cultivable plants, for the bitter lupins could not be regarded as full-value crops.

With the discovery of the non-shattering forms new possibilities in the utilization of the lupins have been opened up. The growing of lupins for grain will now receive an impetus, and it will be possible to employ lupins directly for human consumption. By the employment of lupins, with their high protein content, for human consumption there would be ensured a use of their protein four times higher than that achieved in feeding them to animals. They could take a place beside the soybean and the pea.

The new tasks involved in the use of lupins for human consumption are the improvement of grain shape and colour, meal colour and quality, shelling capacity, etc.

All these were and are problems peculiar to the breeding of lupins. In addition to them, however, the breeder is confronted by a whole series of other tasks common to the breeding of practically every cultivated plant.

In the case of lupins grown for grain, seed yield stands in the foreground of interest. Until now it has not been possible to breed systematically for grain yield, because the lupins could not be harvested without loss. With the discovery of the non-shattering forms this task will merit especially close attention.

When lupins are grown for green fodder, whether as the main crop or as a catch crop, green weight is of primary importance. In this direction also there is room for much progress.

In the growing of green fodder lupins, moreover, sowing costs have a certain degree of importance. Through the breeding of small-seeded forms, provided seed

yield remained equally high, one might reduce the seeding rate and therewith the cost of sowing.

Yet another task to be mentioned is that of breeding for resistance to the principal forms of disease. When lupins, grown as a catch crop, are left in the field late into the autumn and there is occasional stoppgage of growth, they tend to be heavily attacked by mildew, which reduces to a certain degree their value as a feeding stuff. To what extent the diseases of the lupin may be controlled through breeding cannot yet be foreseen, but nevertheless it will be necessary to deal with this problem also.

The sensitivity of the lupin to lime belongs, perhaps, to the phsyiological disease group. This sensitivity is most marked in the yellow lupin, less marked in the blue and least in the white lupin. It might be possible to select forms with a lower degree of sensitivity to soil calcium.

A remarkable phenomenon has made its appearance in the course of breeding the sweet lupin. Some of the blue and the white sweet lupins exhibit more or less serious fertility disturbances, but only under unfavourable weather conditions during flowering (dry, warm weather). These disturbances are correlated to slightly reduced yield, compared with the bitter initial material. As nearly all the alkaloid-free individuals selected from these two species, irrespective of the actual source from which they come, exhibit more or less marked fertility disturbances, there may be involved either a pleiotropic action of the gene for alkaloid content or a linkage with fertility-disturbing genes. In the former case it would be necessary to seek new genes for freedom from alkaloids, such as would not exert this pleiotropic influence. In the second case completely fertile alklaoid-free forms might be found among the cross-overs.

The various lupin species are cultivated in different regions. On account of its early ripening the blue lupin is the species, with the exception only of *Lupinus polyphyllus*, that can penetrate farthest north; and in the north of Europe, therefore, blue lupins are cultivated. Further south (Germany, Poland) yellow and blue lupins are grown side by side. In the Mediterranean region, Hungary and the Balkan States the white lupins flourish. The area devoted to lupin cultivation is considerable in countries other than Germany and Poland, namely, Hungary, Italy, the south of France, Spain, Portugal and Egypt.

	hectares
Poland	167,770 for grain, yellow and blue lupins
Italy	330,000 for human consumption, white lupins
Spain	13,350 for human consumption, white lupins
Egypt	6,254 for human consumption, white lupins

As we are in possession of yellow, blue and white sweet lupins, within a measurable space of time lupin cultivation will be completely reorganized in favour of the sweet lupin. When that is accomplished, not only will the present-day lupin areas be used to better advantage, but a great increase in the proportion of land devoted to lupin-growing will take place, expecially in Mediterranean regions. The sweet lupins will supply a food of high value for human consumption and for animals, and will give

relatively high yields even under the most unfavourable conditions. The white sweet lupin will be of greater importance for all tropical and subtropical regions. To what extent the yellow and blue lupins will pentrate into the white lupin area, and conversely the white lupin into the area of the yellow and blue lupins, future experience will show. It will depend, moreover, upon the results of breeding work still to be done. Thus, for example, the penetration of the white lupin into central and northern Europe is dependent upon the discovery of early forms which can be relied upon to ripen even under unfavourable climatic conditions.

To-day the yellow and blue sweet lupins have already made headway beyond the confines of their homeland, Germany, and are being cultivated in surrounding countries. It will require some time yet for the white sweet lupin to spread through the whole Mediterranean region. The yellow, blue and white sweet lupins will undoubtedly be adopted as new crop plants in every country in which climatic and soil conditions permit the growing of lupins.

A special problem is presented in the breeding of oil lupins. In many European countries, especially in the north, we have no suitable oil plants other than linseed and hemp. Most oil plants grow in the tropics and subtropics. There is therefore a demand for new forms which may be grown in central and northern Europe. Baur pointed out that *Lupinus albus* and *Lupinus mutabilis* might be suitable for the purpose if their oil content could be increased from 10 per cent to approximately 15 or 16 per cent. In accordance therewith I have been engaged since 1932 in the evolution of a technique for the rapid determination of oil content, and have begun to select individuals of *Lupinus albus* having a high content of oil.

Laube, of Petkus, referred to *Lupinus albus* in 1933 as " the German soybean." The Russians have taken up the same problem and have also started to breed oil lupins.

The final objective of oil lupin breeding must be the production of an alkaloid-free oil lupin, of which the remaining parts—after the oil has been extracted—may be used as a feeding stuff without any further treatment. The oil lupins available up to the present time, probably without exception, have been selected from bitter material.

Of the practical importance of the oil lupin no judgment can be formed for the present, as no information concerning its yield of oil per unit area is yet available. It will probably be very much easier to produce oil lupins for the Mediterranean regions, where the time of ripening constitutes no problem. In central Europe, however, an oil lupin must be required to ripen uniformly early. This combination is hard to find.

It will be some years yet before we shall be able to see clearly in respect to the oil lupin and its economic importance.

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SOIL CONSERVATION DISTRICTS IN THE UNITED STATES

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Over the past 50 years soil erosion has cost farmers of the United States approximately 20 billion dollars. Uncontrolled run-off water and low, sweeping winds have stolen away countless tons of fertile American soil, countless tons of available and potential plant food. About 200 million acres of once-productive land in various parts of the country are now severely impoverished or ruined outright for further agricultural use. The spreading damage has extended into every important farming region of the nation and has affected, in some degree, the production of every staple crop.

In recent years the gravity of this vital land problem has been demonstrated by spectacular dust storms, mounting flood heights and crop-destroying droughts. Wind-borne soils have travelled two-thirds of the distance across the continent. Rivers have over-run their banks with frequency and violence as rainwater and melting snows rushed rapidly off eroded hillsides. Drought conditions have been magnified over wide areas as erosion exposed impervious layers of subsoil and reduced the storage of water beneath the ground.

Since 1929 the Federal government has been trying to cope with the national soil erosion problem in a number of ways. Research studies have been carried forward in some of the country's principal agricultural areas. Educational programs have pointed out to farmers the danger of erosion, the necessity for control, and the methods of control. Demonstration projects have etched the soil conservation story on the land for all to see. Monetary grants have been made to assist farmers in the adoption of soil-conserving practices.

For some time, however, it has been recognized that the erosion problems of the United States could never be satisfactorily solved by Federal action alone. The task is too vast, too complex to lie within the scope of a central governmental agency. It involves protective treatment for at least three-fourths of the country's tillable area. It requires a rather intimate knowledge of peculiar local conditions which vary from farm to farm and even from field to field. Federal agencies have an essential role to play. They are needed to point the way toward better land use, to lend advice and assistance to the soil-conserving farmer. But there is a most genuine need for some means to hasten the spread of conservation practices over the extensive are of American farm land suffering from erosion.

To meet this need, the soil conservation district was designed. During 1937, twenty-two of the forty-eight states passed laws permitting local groups of farmers to form these districts for purposes of a co-operative attack on the erosion problem. By the first of March, 1938, thirty-one districts had been organized and dozens more

were somewhere along in the process of formation. Eventually, it is hoped, these districts will cover a significant portion of the country's erodible land surface.

The soil conservation district represents the application of time-honored principles of co-operative action to the solution of a problem the gravity of which has only recently received widespread recognition. The nature of soil erosion, the consequences which follow in its wake, and the character of conservation measures are such that a co-operative attack on the problem appears to be the only feasible way of reaching a solution.

Wind and rain are natural forces. They follow no pattern laid down by man. They respect neither his fence lines or his property lines. Soil carried by water moves from the crests of ridges down to the bottom lands along streams. When a hillside farmer permits soil-laden water to rush off his fields, his neighbors on lower-lying land are virtually powerless to prevent the burying of their crops and the damaging of their soil. Nor is there much an individual farmer can do to prevent a dust storm without the co-operation of his neighbors.

Single-handed combat with erosion can be costly and can never be anything but piecemeal. There is only one style of attack that seems worth while, that seems to hold promise of success; and that is the co-operative attack beginning where the erosion begins, at the crests of the ridges, and working down, field by field, to the stream banks in the valley below. This style of attack would move across a dust area, section by section, until all soils subject to erosion were either covered by vegetation or protected by adjacent areas.

To be really complete, a soil and water conservation program must bring into use all of the known good, practical and economic means of saving soil and water adapted to an area; and it must bring them into use on all of the land, not upon only a segment of it. And this must be done, for practical reasons, in such a way that farmers are able to maintain or increase their income after the conservation measures are applied to their land. The co-ordinated erosion-control program, as a form of attack on the problem, presupposes that with adoption of proper conservation practices and methods of farming, each piece of land will be put to the use to which it is best adapted.

Thus highly erodible slopes and plains would again be clothed with trees or grass, while cultivated crops would be restricted to the less erodible slopes and non-erodible lands. Cultivated fields would be protected by such safeguards as strip crop, terraces and other measures. Soil-saving and soil-improving rotations would displace soil-depleting and erosion-permitting crop systems. Such a program, at least in certain parts of the country, would transform agriculture to some extent, but a transformation is necessary if soil wastage is to be effectively checked. Such a program can succeed only through co-operative effort, neighbor with neighbor, community with community. The soil conservation districts laws provide a mechanism which promises to aid this transformation in a manner acceptable in a democracy.

Each of the laws set up a State soil conservation committee composed usually

of the heads of various State agricultural agencies. This committee is empowered to make the legal determinations necessary in the creation of a district, to encourage the organization of districts, to bring about an exchange of information among districts, and to co-ordinate the several district programs of a state "so far as this may be done by advice and consultation." After a district has been organized however, it is an independent unit and not subject to control of the State committee.

The initiative for forming a district must arise from local needs; it must come from the men who actually work the land. Under most of the laws, a district is created in somewhat the following manner:

Any 25 land occupiers of a given area may petition the State committee to establish a district. The committee is then required to hold public hearings, to determine the boundaries of the district, and to make arrangements for a referendum on the question of creation. In this referendum all qualified occupiers of land (i.e. persons or corporations holding title to or in possession of lands) within the proposed area are eligible to vote. If a majority of those voting express themselves in favor of creation, the State committee appoints two supervisers who request the Secretary of State to issue a certificate of organization. Upon issuance of this certificate, the district becomes a governmental subdivision and is ready to carry out a program of soil conservation.

One of the first jobs facing the newly created district is the election of supervisors. Two are appointed, as mentioned above, by the State committee; but three others are elected by local ballot. In this election, as in the referendum on creation, all qualified occupiers of land within the district are eligible to vote. The three candidates receiving the largest number of votes take their places with the two supervisors already appointed to form the governing board of the district.

Once organized, the district may proceed to carry out a program similar to that now being developed on soil conservation demonstration areas operated by the Federal government. One of the first steps will probably be a conservation survey of the entire district, showing slopes, soil types, prevailing land use practices, and existing erosion conditions. On the basis of this survey, the supervisors can draw up an erosion-control program to meet the needs of the area. Then they may enter into agreements with farmers and help them in developing soil conservation plans for the individual farms. In this work, they may provide the farmers with technical assistance, and make loans or grants of machinery, seeds, planting stock, and other necessary supplies. In some cases, they may also offer the farmers a certain amount of financial assistance. In furtherance of its objectives, the district may enlist the assistance of State and Federal agencies through the medium of the State soil conservation committee.

Generally, the district supervisors may also exercise another set of powers. In some cases, the negligence of a few recalcitrant farmers may seriously endanger the success of the whole district program. Under such conditions, the supervisors are empowered to draw up land use regulations for submission to a referendum vote. If approved by a majority, such regulations assume the force of law and become

operative on all lands within the district. In principle, these regulations are similar to urban zoning ordinances, town building codes, and the like. They simply prevent any individual from using his land in a manner that is detrimental to the entire community. In areas subject to dust storms, for example, a regulation might be adopted which would require contour listing of all blowing land that is a hazard to other lands. In humid parts of the country, a regulation might require the retirement of certain badly eroded hillsides to trees or grass to protect lower-lying fields from excessive run-off or silt deposition.

To prevent such regulations from causing undue hardship to any individual farmer, a board of adjustment can be set up in a district. Any farmer may apply to this board for exemptions from the strict letter of the regulations, and he may appeal decisions of the board to the courts of the State. In this way, the rights of the individual are protected. The soil conservation district has been called an attempt at "democracy in land use." And surely, no institution could be more democratic. The final decision on all important questions rests with the men who till the land and live by its products.

The possibilities of beneficial accomplishment by these districts are great. They should help to preserve the soil of the United States and maintain its usefulness for future generations. In arid sections of the country, they should aid in the fight against drought conditions and dust storms. In more humid regions they may contribute to the reduction of flood hazards. Wherever established, they should cut down the costly damage of silt deposits on valley agricultural lands, in reservoirs and in harbors.

Whether farmers in the districts will enjoy increased crop yields per acre and added income after a few years of soil-conservation-type operations cannot be accurately predicted because of the large number of imponderable factors. It seems reasonable to assume, however, that the outlook for improved crop yields per acre over a period of years will be brighter. When soil, moisture, plant food and organic matter are held on farms by conservation measures, the chances of plentiful harvest are naturally better than when these valuable assets are permitted to wash down the creek with every heavy rain.

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REVIEWS

IMPROVEMENT OF MOORLAND GRASS

[Reviewer : G. M. Roseveare]

Instructive seven-year experiments in the improvement of moorland grass, carried out by the Prussian Moorland Experiment Station at Bremen (Director: Prof. Brüne) are described by Dr. C. Husemann in *Jahrbuch der Moorkunde.**

In the region about Bremen over two-thirds of the agricultural area are under grass. Some is situated on light, medium heavy and heavy river marsh soil, but the greater part is on low moor soils of varying kinds : all of these are very valuable grassland soils of high water-retaining capacity. Yield is in general far from proportionate to the valuable quality of the land, for the following reasons.

(1) In some parts (approximately 3,000 hectares) drainage is inadequate, there is insufficient protection from river flooding, the water table is high (10 to 40 cm. from the surface), and the land is often flooded for weeks at a time not only in winter, but also in spring and summer.

(2) The greater part of the region's grassland, or approximately 10,000 hectares, has long enjoyed good drainage ; but there has been a neglect of the other measures necessary to make this drainage effective, namely, the construction and maintenance of inland drains and ditches to intersect the land between the main drains ; the use of pumps to lower the water table in winter ; manuring ; ploughing up and resowing or scratching and sowing, as the case may require.

(3) Land belonging to certain co-operative associations (approximately 4,000 hectares are concerned) is customarily watered with town refuse water. The excessive use of this practice, combined with neglected drainage, a one-sided use of the land and generally poor management, has resulted in greatly deteriorated botanical composition.

The Station's experiments were designed to show the farming community how such land might be transformed into profitable meadows. For reasons of space the author has been unable to give an account of the experiments conducted in the land described under (3) ; and those in the first type of land had to be abandoned on account of the lack of drainage—the spring and summer floods in particular made it

*Husemann, C. Siebenjährige Umbruchs- und Ansaatversuche auf Niederungsmoorwiesen im Bremer Gebiet als Beispiele erfolgreicher Grünlandverbesserung. [Seven-year experiments in the breaking up and resowing of low moor meadows in the Bremen district as examples of successful grassland improvement.] *Jb. Moork.* **24. 11-32. 1937.**

impossible to establish any sowing, even of the so-called "flood mixtures." A full account is given, however, of experiments carried out in two localities on land most typical of the region, which is described above under (2).

First Locality

In the first locality there was taken in hand in 1930 an area of half a hectare, heavily overgrown on one side with *Carex stricta* mixed with a small proportion of *Calamagrostis lanceolata*, and having on the other side a poor sward of *Agrostis canina*, *Calamagrostis lanceolata*, *Carex* spp., *Phalaris arundinacea*, *Holcus lanatus*, and many weeds. The conditions and history of the experiment, briefly summarized, are as follows.

Soil. Well disintegrated sedge peat with a small admixture of fine sand, almost free of clay; transition moor with satisfactory calcium content (2.16 per cent). Subsoil of moist, permeable sand.

Water table. On an average 60 to 80 cm. below the surface during the growth period.

Treatment. April, 1930: burned, three times disk-harrowed and rolled (heavy water-filled roller drawn by a tractor), the third time fertilizers worked in. Sown April 25.

Manurial treatment. Basic slag and 40 per cent potassium salts, in the following quantities. 1930, per hectare, 700 kg. P and 350 kg. K. 1931, per hectare, 400 kg. each, P and K. 1932-37, each year, early in the spring, the same fertilizers, quantity being calculated on the basis of 20 kg. pure K_2O and 6.5 kg. pure P_2O_5 for each 10 dz. air-dry hay (with 15 per cent moisture content) harvested in the previous year. The same quantities of P and K as those given in 1932-37 were also applied, from 1933 onwards, to a neighbouring plot of the original, untreated sward. No nitrogenous fertilizer was used.

Seeds mixture. 44 kg. per hectare, as follows (the figures indicate kg. per hectare): *Phleum pratense*, 5; *Phalaris arundinacea*, 1; *Festuca pratensis*, 10; *Lolium perenne*, 6; *Poa pratensis*, 8; *Poa fertilis*, 2; *Beckmannia eruciformis*, 2; *Avena elatior*, 4; *Agrostis alba*, 2; *Cynosurus cristatus*, 2; *Lotus uliginosus*, 1; *Trifolium hybridum*, 1.

Harvesting. One cut, 69.84 dz. air-dry hay, taken from the new sowing in the seeding year, 1930. 1931-36, two cuts taken annually, from June 7 to 14, and August 14 to 22 respectively, from the new sowing, from the unmanured control, and (1933 onwards) from the manured original sward. Yield of air-dry hay with 15 per cent moisture content was calculated on the green weight from four 25 sq. m. sample plots, studied in the laboratory for dry matter content. The yields obtained in the different years for the different cuts are presented in a table. Annual yield, average of the six years 1931-36: for the disked, resown and manured area, 100.47 dz. per hectare; for the unmanured, original sward, 26.72 dz. per hectare. Average of the four years 1933-36 (expressed in dz. per ha.): the disked, resown and manured area = 104.45; the manured, original sward = 42.90; the unmanured, original sward =

19.82. The new sowing gave good grazing for five dairy cows after the second cut, except in 1936, when a third cut was taken. The superior results of breaking up and resowing, contrasted with manuring only, are evident.

Costs. These are calculated on prices current in 1936. The cost of tillage, seed and fertilizers (1930-36) on the improved land amounted to RM. 645. On this land in six years (1931-36) 442.52 dz. more hay was obtained per hectare than on the unmanured control, the minimum value of the increase being RM. 1,770. Thus a net increased profit of RM. 1,125 was obtained, and the cost of resowing and manuring was more than covered by the increase of the first two years alone. Herein the quality of the hay does not enter into consideration.

Quality of the hay. (a) Botanical composition. Four years' manuring of the original *Agrostis canina* sward resulted in an increased proportion of *Phalaris arundinacea* and of *Calamagrostis lanceolata*, but at the same time greatly encouraged the growth of weeds such as *Lychnis flos cuculi* and *Thalictrum flavum.* The improved botanical composition of the new sowing, on the other hand, has been maintained to the present day: it exhibits a close sward with *Poa palustris*, *Phleum pratense*, *Phalaris arundinacea* and *Festuca pratensis* dominant, smaller proportions of the other components of the seeds mixture, and traces of *Lychnis flos cuculi.* (b) Protein content. On the resown area, crude protein content for the last three cuts of 1936 was 9.63, 13.20 and 12.11 per cent respectively. The yield of crude protein per hectare was 11.89 dz.

Second Locality

In the second locality (one in which it had been customary to flood meadows excessively with water from the neighbouring river Wümme), an area of 0.76 hectare was used.

Original sward. Dominant, *Alopecurus geniculatus*, *Agrostis canina*, *Carex* spp., *Acrocladium cuspidatum*, *Cardamine pratensis*; in smaller proportions, *Poa trivialis*, *Aira caespitosa*, *Lysimachia nummularia*, *Alopecurus pratensis*, *Ranunculus* and *Agrostis alba.*

Soil. Well disintegrated low moor (sedge peat), interspersed with mud. Calcium and general nutrient content satisfactory, but solubility, especially in the case of phosphoric acid, unsatisfactory. Under the 20 cm. humus top soil an uneven layer (10 to 40 cm.) of pure mud.

Water table. This is too high, and there is insufficient aeration. In winter at the best 20 to 40 cm., in summer 40 to 60 cm. below the surface.

Plan of experiment. Of the original sward 0.13 hectare was left unmanured as control, 0.13 hectare was limed and manured, and two areas, each of 0.25 hectare, were divided off by 50 cm. high surrounding banks, and were broken up, limed, manured and resown, one of these two areas being referred to as "New Sowing A," the other as "New Sowing B." The intention was to test plot A as a water meadow, subjected to periodic flooding, and plot B as an example of dry farming; but owing to technical difficulties the watering of A could be carried out only at the beginning of the experiment (it was flooded 15 cm. deep December 17 to 23, 1930, and March

26 to April 4, 1931), so that from 1932 onwards both plots were dry-farmed. A and B were each divided into two halves, one of which was limed, the other not.

Treatment. Plots A and B, disk-harrowed twice, April 23, 1930, one-half of each plot dressed with lime and both with KP at the second harrowing, sown down April 26, sowing rolled in twice, top dressing of N.

Manurial treatment. This applies to A and B and also to one 0.13 hectare plot of unsown original sward. Per hectare, 1930, 50 dz. finely ground marl (applied to one-half only of the A and B plots), 100 kg. pure P_2O_5 in basic slag, 120 kg. pure K_2O in 40 per cent potassium salts, 30 kg. N in soda saltpetre. 1931, the same amount of P_2O_5, and the same amount of N applied in 15 kg. doses before the first and second cuts respectively. 1932-36, annual dressings of basic slag and 40 per cent potassium salts at the rate of 50 kg. pure P_2O_5 and 60 kg. pure K_2O. Throughout the experiment K and P were applied between March 16 and April 6.

Seeds Mixture. 42 kg. per hectare of the following "flood-mixture" (the figures indicate kg. per hectare): *Phleum pratense*, 5; *Phalaris arundinacea*, 2; *Festuca pratensis*, 15; *Poa fertilis*, 4; *Beckmannia eruciformis*, 2; *Poa pratensis* (American), 6; *Agrostis alba*, 3; *Cynosurus cristatus*, 2; *Lotus uliginosus*, 2; *Trifolium hybridum*, 1.

Harvesting. Two cuts were taken annually from 1931 to 1936. As in the other experiment, yield was calculated from the green weight of sample plots, studied in the laboratory for dry matter content. The figures for average annual yield for the five-year period 1932-36, when dry-farming was carried out on both A and B, are, in dz. per hectare, as follows: control, 42.30; original sward, limed and manured, 60.98; plot A, not limed, 72.49; plot A, limed, 67.36; plot B, not limed, 75.24. For the limed part of plot A, 76.41 dz. more hay per hectare than on the limed and manured original sward is recorded in the first three years; the value of this increase, RM. 305.64 per hectare, more than covers the cost of breaking up and sowing, which was RM. 220 per hectare. The effect of liming was rather to depress yield and to produce an unfavourable alteration in the composition of the sward.

Manuring with potassium. A four-year subsidiary experiment was conducted in plot A, varying doses of K_2O being applied in fourfold repetition to plots, 25 sq. metres in size, on both the limed and unlimed areas. The effect of lime and potassium (a) upon hay yields, 1933-36, (b) upon potassium content, 1933-35, and crude protein content, 1936, is tabulated. Results are discussed in relation to the soil. An increase in potassium content is recorded in 1934 and 1935, but even so it does not amount to as much as 2 per cent. No favourable influence upon crude protein content was exercised.

Artificial watering. The yield of plot A, watered in 1931, was actually lower than that of the unwatered plot B, both in the year of watering and on an average of the subsequent years also. In this connexion the injurious effect of the high winter water table is specially noted; it is reflected in the steadily diminishing yields of the last three years of the experiment.

Farmyard manure. A subsidiary one-year experiment in plot B (plots of 25

sq. metres in triplicate) tested the effect of 200 dz. farmyard manure applied in autumn and spring respectively. An immediate increase of yield (1936) is recorded, together with increased closeness of sward. It is noted, however, that the application of N in artificial fertilizers is unprofitable on well aerated moor. On insufficiently aerated low moor nitrogenous fertilizers are satisfactory in increasing hay yield, but in the long run result in patchy swards with an excessive proportion of top grasses.

Botanical composition. Analysis in August 1936 gave the following results (in percentage) :

	Bare patches and moss	Weeds	Poor grasses, *Carex* etc.	Good grasses	Legumes
1. Unmanured control	42	19	34	4	1
2. Original sward, manured and limed	3	12	29	48	8
3. Plot A, limed	18	7	15	57	3
4. Plot A, unlimed	18	7	8	64	2
5. Plot B, unlimed, no farmyard manure	15	5	8	69	3
6. Plot B, unlimed, with farmyard manure	10	7	7	72	4

Dominant on the manured original sward, which was very close, were *Poa trivialis* and *Calamagrostis lanceolata*, together with smaller proportions of *Trifolium repens*, *T. pratense*, *Lathyrus pratensis* and *Agrostis alba*. On the new sowings A and B *Phleum pratense*, *Festuca pratensis*, *Poa fertilis* and *P. trivialis* were dominant. The proportion of legumes in the new sowings was unsatisfactory ; it is considered that probably white clover should have replaced *Trifolium hybridum* in the seeds mixture.

Protein yield. A study of protein yield in 1936 shows that by liming and manuring the original sward and by applying KP to the new sowings crude protein yield was increased by approximately 20 per cent. By dressing with farmyard manure in addition (1936), the crude protein yield of the new sowing was increased by a further 50 per cent. The new sowing B gave in 1933 a crude protein yield of 9.13 dz. per hectare. Feeding trials are necessary for a final estimate of protein yield.

General conclusion. On low moor soils of this nature, interspersed with mud and having a winter water table 20 to 40 cm. below the surface, the success of new sowings cannot be guaranteed ; the use of KP alone may have an equally good, or even better effect in the course of time. The practice of watering exercises no directly beneficial results, and may be extremely detrimental in regard both to yield and to botanical composition.

INTERNATIONAL LUCERNE TEST

[Reviewer : G. M. Roseveare]

In *Herbage Reviews*, Vol. 1. pp. 125-31. 1933, an account was given of the organization of an international lucerne test by the Herbage Bureau. Data were collected in a number of centres in different parts of the world and were collated and distributed in mimeographed form from the Bureau. Observations have now practically ceased, although annual reports of great interest are still being received from the centre at Szeged, Hungary. The Bureau hopes to be able to group all the data together in a final report as soon as other work permits.

In the meantime, a report has been published of another international lucerne test, organized by Professor Koenekamp in 1929 [*Pflanzenbau*, 14. 161-99. (English summary, 198-9.) 1937.] Trials of eleven varieties were conducted at his own Institute, the Grassland Institute of the Agricultural Research Station, Landsberg on the Warthe, Prussia (six years), and in the following countries : Rumania, at Feldioara (one year only) ; Hungary, Szeged (three years) ; Magyar-Ovar (five years) ; South Africa, Middelburg (four years) ; U.S.A., Lincoln, Nebr. (three years) ; North Ridgeville, Ohio and Westpoint, Miss. (one year only in each case). The varieties tested were the German Old Franconian hybrid lucerne, American Grimm, Rumanian or " Siebenburg " lucerne, three Hungarian lucernes, two Turkestan lucernes from Khiva and from Fergana respectively, Italian commercial of known origin, Californian common alfalfa, and South African Cape lucerne. A tabular review is presented of the diverse environmental conditions under which the test was conducted. Table 1 shows for each station the geographical situation, giving the degrees of latitude and longitude ; the altitude, which ranges from 70 m. above sea level at Landsberg to 1,203 m. at the Grootfontein School of Agriculture, Middelburg, Cape Province ; average annual precipitation (a) generally (from 344.2 mm. at Middelburg to 1,373.1 mm. at Westpoint, Miss.), and (b) for the duration of the trial in each case (from 311.4 mm. at Middelburg to 1,200.2 mm. at Westpoint, Miss.) ; average monthly precipitation ; average mean diurnal temperature for each year of the trial (ranging from 7.3°C. at the Rumanian station in 1932 to 17.2°C. at Westpoint, Miss., in 1929-30) ; and the average mean diurnal temperature for the different months. Table 2 gives a general review of climatic and soil conditions at each Station, and Table 3 chemical and physical analyses of the different soils. These were either diluvium or alluvium. The land at Ridgeville, Ohio (pH 4.8 and 4.5) and at Lincoln, Nebr. (pH 5.0 and 5.1) was distinguished by unusually high hydrogen ion concentration. Soil conditions were ideal at Middelburg, Cape Province.

As far as possible, the same planting method was adopted by all the stations, namely, sowing in the open or in forcing beds and subsequently transplanting to rows 27.6 in. apart, the plants being set at a distance of 11.8 in. from one another in the rows. The following were the data to be recorded : green weight, determined directly after cutting ; yield of air-dry hay ; content of crude protein ; yield of crude protein ; percentage of winter-killed plants ; time of flowering, flower colour ;

observations on disease, pests and parasites.

Results are discussed under the following heads.

Hay Yield

This is shown in a table, the yield for each station being given in two columns, representing (a) the yield of air-dry hay in dz. per hectare (in the case of Landsberg hay with 85 per cent dry matter); and (b) the relative yield of each variety, the indigenous variety being taken as 100. Two facts are revealed, particularly by the figures given in column (b). One is that the indigenous varieties in every part of the world are as a rule superior to foreign varieties, a finding considered to be of special interest in view of the divergency of opinion expressed by ecologists and geneticists at the Fourth International Grassland Congress at Aberystwyth, 1937. The other fact is the existence of lucerne varieties having an unusually wide ecological distribution, namely, the German Old Franconian, a cross of *Medicago vulgaris* and *M. falcata*, and the Grimm lucerne which originally emanated from it. The extraordinary adaptability of the hybrid lucernes is well illustrated by their behaviour under the widely different conditions of Landsberg, Germany (average annual rainfall 535 mm., average mean diurnal temperature, 9°C.), and of the Grootfontein School of Agriculture, Middelburg, South Africa (average annual rainfall 344 mm., average mean diurnal temperature 15°C.). At Landsberg the hybrid lucernes, Old Franconian and Grimm especially, gave the highest yields, *Medicago sativa vulgaris* being an entire failure. At Grootfontein, *M. sativa* gave the highest yields, but the hybrid lucernes also gave yields very little below those obtained at Landsberg. The figures are as follows :—

	Germany		South Africa	
	dz. per hectare	relative	dz. per hectare	relative
Medicago media	96	100	83	86
M. sativa vulgaris	21	22	96	100

Of nine hybrid lucernes the place taken by the German variety in the different localities was as follows (average of all the years of the trial) :—

	Position
Landsberg, Germany	First
Feldioara, Rumania	First
Szeged, Hungary	Second
Magyar-Ovar, Hungary	First
Middelburg, S. Africa	Third
Lincoln, Nebr.	First (together with three other varieties)
Ridgeville, Ohio	Second
Westpoint, Miss.	Fourth

Protein Yield

The only complete record was kept at Landsberg. At the Grootfontein School of Agriculture, Middelburg, however, a record was kept for the first, second, third and fifth cuts of the 1931-32 harvest, and a comparison of the Landsberg and Middelburg records for nine varieties is presented in tabular form.

Protein content. In South Africa this is in general 2 to 4 per cent (in the Italian lucerne 5 per cent) higher than in Germany. The cause for this is perhaps the greater number of cuts which have been taken in South Africa (Middelburg six, Landsberg three). Little varietal difference in protein content is recorded, and where a difference is seen, it is probably due not so much to varietal character as to greater or less rapidity of growth. For example, Hungarian lucerne at Landsberg developed more rapidly after cutting; when mown together with other varieties it was therefore more mature than the others and protein content was accordingly lower. Protein *yield* is primarily governed by the hay yield and not by protein content. In consequence it ranges at Landsberg from 3 to 18 dz. per hectare, while at Middelburg it is remarkably uniform, approximately 17 to 21 dz. per hectare. Although the difficulty of growing lucerne under northern climatic conditions is thus demonstrated, the good results which may be obtained from using the indigenous hybrid lucerne are also demonstrated, for the Old Franconian gave 18.3 dz. crude protein per hectare at Landsberg. Grimm (15.3 dz. per hectare) and the Rumanian Siebenburg variety (14.5 dz. per hectare) greatly exceeded the Hungarian, Italian and Russian varieties in protein yield at Landsberg. It is noted that under conditions in East Germany no plant can supply so much protein per hectare as lucerne, red clover being the only other which approaches it in this respect.

Construction of Yield

The test furnished information on the following points :

(i) *Yield in the different years.* Data were available from four stations, representative of the northern temperate zone and the southern, subtropical zone, namely, Landsberg, Germany; Magyar-Ovar and Szeged in Hungary; and Middelburg, South Africa. In a graph showing yield in the different years (in each case for the indigenous variety) a peak, followed by a steady decline, is reached for Landsberg in the fourth year, and for the two Hungarian stations in the second year. For Middelburg, on the other hand, a fall from the first to the second year is recorded, followed by a sudden sharp rise. It is assumed that this rise continues for another one or two years, but unfortunately no data are available after the fourth year.

(ii) *Yield in relation to the number of cuts taken.* Not only is yield affected, but also its reliability and the protein content of the crop vary in accordance with the number of cuts taken. At Landsberg crude protein content was found to be on an average 2.3 per cent higher when three cuts per year were taken (compared with two cuts per year). A comparison of the number of cuts taken at Landsberg in Germany, Magyar-Ovar and Szeged in Hungary, and at the South African station

shows that under the more severe climatic conditions of the northern, temperate zone not more than three cuts can be expected, and frequently only two ; farther south (as at the Hungarian stations) a fourth may be added, and in subtropical regions four or five cuts are usual, but the additional cuts do not augment the total yield per year to any marked extent. It is always the first cut, and to a lower degree the second, which are decisive for the year's yield. The first cut in particular is largely independent of seasonal rainfall, for, in a dry spring, when grass and clover-grass would fail, the deep-rooting lucerne can obtain sufficient moisture from lower soil moisture reserves.

(iii) *Yield per unit area in relation to density of stand and individual plant yield.* This question is studied principally on the basis of the data obtained at Landsberg and Magyar-Ovar, yield per unit area being taken as the product of stand density (that is, the number of plants per sq. metre) and the yield of the individual plant. It is found that although the density of stand seen just after sowing is of short duration, since there is a more or less great diminution in the number of plants from the first year onwards, yield, far from declining, rises in the second, third, and sometimes in the fourth year also, owing to increased tillering on the part of the individual plants. (The attention of the breeder is called to the value of the character " tillering capacity "). In general, indigenous and foreign varieties differ perceptibly in their ability to contribute to yield in this particular manner. It is apparent that if wide planting distance results in the greater productivity of the individual plant, a low seeding rate is advisable. Seeding rate experiments conducted at Landsberg in 1936, with spring and autumn sowings, are quoted to show that : (a) early spring sowing is always preferable to autumn sowing, yield being approximately doubled ; (b) with spring sowing, a low seeding rate produces as good yields as a high seeding rate ; (c) with autumn sowing higher seeding rates, up to a certain point, produce better results, but after this point increased seeding rate may actually depress yield again. Under conditions in the east of Germany the sowing of more than 20 kg. per hectare serves no useful purpose and may even prove detrimental to yield.

Soil in Relation to Yield

Data on soil type and on the chemical and physical structure of the soil at the various stations are presented in Tables 2 and 3. In general, soil type and the nature of the soil appeared to have little perceptible effect on yield. Certain broad indications of favourable or unfavourable effect exercised by soil conditions upon the yield of indigenous varieties at seven stations are, however, noted as follows :

(1) Three stations at which the best yields, averaging over 100 dz. per hectare, were obtained, namely, Feldioara, Rumania ; Landsberg, Germany ; and Middelburg, South Africa. At these stations pH was approximately 7 in both upper and lower soil levels, and neither the low mean diurnal temperature at Feldioara and Landsberg nor the rather high water table (2 m.) at Feldioara were able to counteract the favourable effect of the neutral soil reaction.

(2) Four stations at which the lowest yields were obtained, namely Lincoln,

Szeged, Ridgeville and Westpoint. At Lincoln and Ridgeville, soil acidity (pH 5.5 and 5.4 respectively) is probably responsible. At Westpoint the physical structure of the soil, a heavy, loamy clay, is unfavourable for water movement and for the oxygen content of the soil water, and the same condition, perhaps in conjunction with high water table, is probably responsible for the low yield at Szeged. High water table alone, *when not stagnant*, does not appear to have a detrimental effect upon yield.

Proportion of Stem, Leaves and Flowers Related to Chemical Composition

Information on this subject is available from the Grootfontein School of Agriculture only. Data for 1931-32 and 1932-33 are given in a table. Varietal differences are not marked.

Stem and content of crude fibre. The lowest proportion was found in the German hybrid lucerne, the highest on the whole in the Russian Fergana variety. A high proportion of stem appears to be correlated to high crude fibre content.

Proportion of leaf and protein content. Fergana was the leafiest variety in both years, but its protein content was moderate to low. The South African indigenous variety, which was among those with the lowest proportion of leaf, nevertheless exhibited the highest protein content in the second year. In lucerne there does not appear to be so positive a correlation between proportion of leaf and content of protein as in, for example, the grasses.

Protein and crude fibre content. The South African variety in the second year united with the highest crude protein content the highest crude fibre content also.

Flowering. The Russian varieties Khiva and Fergana, together with Grimm, are the types poorest in flowers, and are thus late-ripening under Cape Province conditions. The German Franconian, like Grimm a hybrid, proved early-flowering even under environmental conditions totally different from those of its native habitat. At Landsberg the hybrid lucernes flowered five days earlier than the other varieties; the Russian and the Cape varieties were late. It is noted that lucerne cannot be judged by the same criteria as other forage plants, and that more attention must be paid to its peculiarities by the breeder if full advantage is to be taken of its valuable properties.

Diseases, Pests and Parasites

These are listed, with a note of the damage caused and the generally greater susceptibility to attack of foreign varieties, *M. sativa vulgaris* especially.

THE FODDER MALLOW

[Reviewer : G. M. Roseveare]

During the last two or three years experiments in the use of the mallow have been made in various parts of the Continent. Information is available chiefly from Germany, where, in view of its high protein content, the plant is receiving careful consideration. The area devoted to its cultivation, still at the experimental stage, was increased by more than 5,000 hectares in 1937. In Germany there are three main varieties, which do not appear to differ greatly from one another. They are " Draeger's mallow," " Ackermann's green fodder mallow," obtainable from Gerhard Schneider, Seedsman, Niederwalluf i. Rheingau ; and " Lampe's fodder mallow," bred by Ernst Lampe and obtainable from him at Altdamm, Pomerania, Kleinfelderweg, 1. Lampe's mallow has been selected from *Malva verticillata* L. While the original species, a medicinal plant probably emanating from China and found in many parts of Germany, is a biennial, Lampe's strain is an annual. There are two forms, the smooth-leaved and the crispifolious, the latter being the more leafy and having a higher protein content (**25**). The plant has a tap root which does not penetrate to any great depth, and the lateral roots are spread in a shallow manner in the upper soil. For this reason the water requirements of the plant are unusually high (**8, 14**).

Cultivation

Early reports are on the whole unfavourable. Koch, reporting in 1935 on trials conducted in all parts of Germany during the previous year, notes the very large proportion of complete failures and considers the mallow of no value as a forage crop (**10**).* The dry weather of 1934 should, however, be taken into consideration. On the basis of experience in 1934 a farmers' weekly states that the use of the plant " in its present form" for grain or fibre production in Germany is out of the question (**24**). On the other hand Weller reports that successful results were obtained at the Weihenstephan Seed Breeding Station in 1934 (**22**). The crop was sown on June 27 on good loam soil in 30 cm. drills at the rate of 4 kg. per hectare. It reached a height of 2 metres and presented a close stand. The harvest, taken on October 15, amounted to 275 dz. green weight per hectare, protein yield 533 kg. per hectare.* The crude protein content in the dry substance amounted to 10.69 per cent. The crop was ensiled and gave silage of very good quality. The quantity of protein obtained is considered noteworthy. The plant's slow early development is noted as its principal disadvantage.

In 1935 experiments were made by Sessous and Schell at the Plant Breeding Institute of the University of Giessen (**19**). In the first trial the plants were sown on May 10 at the rate of 2.5 kg. per hectare in 30 cm. drills. Early development was uneven and there were many bare patches ; but the stand improved greatly by harvest time, although there were still some bare patches that were probably re-

*10 dz. per hectare = 8 cwt. per acre.

sponsible for the not very high yield of 137 dz. per hectare (first cut) and 111.3 dz. per hectare (second cut). It is considered that germination vigour was probably superior to shooting vigour. The second trial was sown on heavy loam in sixfold replication, the plots being 75 sq. m. in size. Silo maize, sunflowers and Sudan grass were grown, also in sixfold replication, for comparison. The stand was somewhat better than in the first trial, but still not sufficiently close to justify the forming of an opinion for or against the mallow. One cut only was obtained from the mallow, from Sudan grass two cuts. In the tabulated presentation of results it is seen that although inferior to the other plants in yield of green weight, in its one cut the mallow is not far below the two cuts of the Sudan grass. In yield of dry matter the inferiority of the mallow is more evident, but in crude protein content it is superior to all the other plants.

In Pomerania, in the same year, the Agricultural Adviser, Dr. Kahsnitz of Stettin, reports successful experiments in the growing of Lampe's mallow (**8**). The following are some of the conclusions drawn and results obtained.

(1) *Sowing.* The best time is from the end of April to early May. Sowing too early in cold soil results in retarded germination and in weed growth. The seed should be drilled not more than 1 to 2 cm. deep in well-tilled ground, with a distance of 35 to 40 cm. between the rows. Seeding rate : when grown as the principal crop, 2 to 4 kg. per hectare ; when grown after cereals, 4 to 6 kg. per hectare.

(2) *Water requirements.* These are unusually high. Optimal results were obtained in land with a high water table, on low moor and transition moor. The crop was more or less a failure on light land with precipitation of barely 500 mm.

(3) *Lime.* In pot trials the plant flourished in neutral to slightly alkaline soil (pH 6.8 to 7.5), but was stunted in sour soil (pH 4.8).

(4) *Manurial treatment.* Pot trials have shown the plant's requirements in nitrogen to be high, and its reaction to phosphorus also very marked. It is estimated that in order to obtain two cuts there must be applied, in addition to farmyard manure, at least 40 kg. pure N per hectare [32 lb per acre] ; for three cuts 60 kg. per hectare [48 lb. per acre].

(5) *Yield.* On low to transition moor, sown on May 5, three cuts were obtained, namely 184 dz. per hectare (July 12), 221 dz. per hectare (Aug. 20), and 144 dz. per hectare (Oct. 22) ; total 549 dz. per hectare. The yield of two cuts on third class soil was 510 dz. per hectare ; of three cuts on second to third class soil 401.2 dz. per hectare ; of two cuts on light, dry, neutral sixth class soil only 160 dz. per hectare.

Shortly after the publication of the above report Dr. Geith, of the Reichsnährstand, Berlin, and of the University of Leipzig, on the basis of experience communicated by the Experimental Station, Rostock, and the experience of the Giessen Plant Breeding Institute confirms many of Kahsnitz' findings (**5**). He agrees with the necessity for shallow and not too early sowing, recommending the beginning to the middle of May, in accordance with soil and climate, and fully confirms the heavy water requirements of the mallow. Whether water is supplied in the form of precipitation or by a relatively high water table appears to be more or less immaterial.

The unsuitability of the plant for use in light land was also confirmed. Yield is reported to vary considerably, and to reach approximately 350 to 400 dz. per hectare with well limed soil and the liberal application of N to encourage bulk production.

In a farmers' weekly Kannenberg and Wrede (**9**) give an account of the successful result of growing mallow as a catch crop at Neu-Hammerstein. Sown on August 8 and harvested on October 17, it gave a green weight yield of 304 dz. per hectare and a digestible crude protein yield of 11 dz. per hectare. (The figures for crude protein yield in other crops, in dz. per hectare, were found to be: mustard-rape, 5.15; sunflowers, 5.30; bean mixture, 5.09.) Some difficulties encountered in the use of mallow as silage are considered by them to render further research desirable. Unglaub's experiments at the Landsberg Research Institute (**21**) furnish useful information on the relation of seeding rate (which should not be too low) to yield. Instructions for the sowing, manuring and harvesting of Lampe's mallow are given by Hartwig (**6**) in a popular journal; and more detailed instructions are published a year later in the same journal by von Ramin, of Zippendorf, Mecklenburg, who considers the chief value of the plant to consist in the producing of protein on land which, on account of too high a water table, is useless for lupins and lucerne (**14**). He notes that the soil must be at all events neutral, as not the least trace of acidity is tolerated by the mallow. Liming is therefore of great importance. Although a high water table is desirable, stagnancy has a very bad effect. The soil must be not too light, nor too heavy and easily crusted, but warm, well aerated, with good humus content. Not only are water requirements heavy, but cultural and manurial requirements also. He suggests 40 to 50 cm. drills, in less favourable circumstances 30 cm.; seeding rate 4 to 6 kg. per hectare. Grown as the main crop, sown in May, approximately 500 dz. green weight per hectare may be expected, the crop having a protein content superior to that of maize, marrow stem kale and other plants, and approximately equal to that of lucerne.

Nutritive Value and Use

In connexion with Sessous and Schell's trials at Giessen in 1936, Horn and Muehl conducted three feeding trials at the University's Institute of Agricultural Chemistry (**19**). The material was that grown in Sessous' trials, fed as the only ration, freshly cut and chopped, to sheep. The digestibility coefficient for the crude protein, the content of which in the dry substance was 16.18 per cent, amounted on an average of all the trials to 78 per cent; crude fat was 75.6 per cent, crude fibre 25.1 per cent, and nitrogen-free extract substances 77.4 per cent. The average percentage of digestible protein and kg. starch equivalent determined were: in the green weight, 1.42 and 7.74 respectively, in the dry substance, 9.14 and 48.1. Protein content was found to vary considerably: it was lowest in material from the first trial, higher in the first cut of the second trial, and in the second cut of the second trial almost double that of the material from the first trial. It is considered that the time of harvesting is of importance in relation to protein content. Comparison of the figures obtained with the figures given in Kellner's tables shows that the green mallow,

in the digestibility of its nutrients, may be compared with red clover in flower or with lucerne in flower. The animals took the mallow readily, although in the first two trials the crop was rather old, and they even took the hard stems when these were finely chopped.

In the same year Wochlbier, Schramm and Herold tested the nutritive value of samples of Lampe's mallow obtained from various growers (**25**). Chemical analyses of the various samples showed that during the first period of the plant's development crude protein content decreases and crude fibre increases as age increases. When the main stem has reached its normal height, a great development of leaves and lateral shoots sets in, whereby the proportion of tender, nutritive leaves and leaf stems is greatly increased and with it the average content of nutrients improved. At the same time there is a considerable proportion of much lignified, poor stems. Feeding trials to test digestibility demonstrated little fodder value in mallow hay or straw made in the ordinary way. On the other hand the nutrient content of the green mallow or of artificially dried mallow hay is considered satisfactory. Sheep again were the animals used.

At the University of Halle Froelich and Loewe made a special study of the nutritive value of the seed (**3**). Their experiments proceeded from 1934 to 1936, and were concerned with the seed's content of crude nutrients, with its digestibility, and with the effect upon milk production and the fat content of the milk. The animals employed were sheep and dairy cows. On the basis of the results obtained the seed is regarded as a serviceable feeding stuff, especially when the fat is removed, of medium protein content. Progress in breeding and improvement in the technique of hulling and removing fat may produce still better results in the future. The effect upon the fat content of milk was to increase it.

In 1937, Bitsch presents another short report of feeding trials conducted at the Institute of Agricultural Chemistry, University of Giessen (**1**). Lampe's smooth-leaved mallow was fed to sheep, pigs and cows. Chemical analyses of the plant at different stages of growth demonstrate an enormous difference between the nutrient content of the leaves and stems respectively. The mallow should be cut not later than the beginning of the flowering period. Under these conditions it is found to be a digestible plant rich in protein, palatable to cows and sheep, the leaves being readily eaten by pigs also. Successful results were also obtained from the use of silage made from mallows. When cows were fed with mallows or mallow silage, the amount of milk always decreased, but the percentage fat content always increased. The following are the figures given for percentage increase in the fat content of milk; rations of green mallow cut when in flower, 0.33; young green mallow, 0.42; mallow silage, 0.20 to 0.25. In spite of the diminished quantity of milk, the total amount of milk fat produced in the mallow ration period was rather higher than in the control period, in the case of young mallow feeding by as much as 8.87 per cent.

Windheuser (**23**) reviews and summarizes the literature on the nutritive value of the mallow. He points out that it is subject to great variation. Nutrient content is highest from the early stages of the plant up to the time of maximum leafiness.

When harvested at the correct time, nutrient content is satisfactory, and the mallow may play a significant part in furnishing protein. The principal use of the plant will probably be as green fodder ; it seems not so well adapted for ensilage.

Richter and co-workers have been studying nutritive value at the Animal Research Station, Kraftborn (formerly Tschechnitz) (**17**), and their report (**18**) appeared subsequent to the above-mentioned summary by Windheuser. They employed Lampe's smooth-leaved mallow, grown in spring after the Landsberg mixture and fed to pigs, sheep and dairy cows. The narrow ratio of protein to starch equivalent is noted. For pigs the mallow is only 58 per cent digestible, even in the early stages (approximately 60 cm. high), so that while it may be employed for the feeding of young and breeding pigs, it is not suitable for fattening purposes. For dairy cows it is considered to supply a thoroughly serviceable protein feed when used green, chopped and amply supplemented by carbohydrate rations.

Geith (**5**) notes the higher protein content of the plant when grown in good soil.

Most of the writers mentioned, with the exception of Woehlbier and his co-workers, report the plant to be palatable. Richter (**18**) writes that the cows were given a short period to become accustomed to the new feed, and then, receiving it at the rate of 50 kg. per cow per day, exhibited good appetite and health.

Ensilage appears to present certain difficulties, although the silage has proved palatable and of good nutritive value (**1**). The position in regard to the use of the mallow for hay is not yet quite clear. Geith (**5**) reports a loss of 50 per cent of the total nutrients, protein in particular, even when the most careful technique was employed. Woehlbier and colleagues (**25**) obtained good results at Rostock in the case of mechanically dried hay, but under the ordinary methods of haymaking the losses of both crude and digestible nutrients were very great on account of the difficulty with which the mallow is dried (in the Rostock experiments several weeks were required even under the driest and best weather conditions), and the use of the mallow for hay is thus considered impracticable. Bitsch (**1**) reports careful drying in small bundles on Swedish fences or frames, but the stems did not dry sufficiently to carry although the leaves had become so dry that the least shock caused them to fall. He notes, however, that haymaking was not begun until the end of August, and that results are therefore not conclusive. Hartwig (**6**) describes hay-curing technique, namely, the arrangement of eight to twelve small bundles crosswise, and says that such bundles dry with relative rapidity, but does not quote actual instances of success.

Farmers' Opinions

The greatest diversity of opinion is expressed by farmers who have experimented with the crop. The Rostock Agricultural Experiment Station sent out an enquiry to thirty-four growers, and received sixteen replies. A summary of these (**25**) is of interest in that no two answers are alike. Only in one case is good development of the crop reported, though this was slow in the early stages. In some cases it failed entirely. In others it was more or less satisfactory. Some growers found that animals took the plant readily, others had a contrary experience. In a popular

journal the Countess Bredow (**2**) reported good yields in 1935 and the successful use of the mallow in feeding all kinds of animals, including pigs. To the last-named it should be fed green, chopped, at as early a stage of the plant as possible.

In 1937 a brief note on experience in Thuringia appeared in the leading farmers' weekly, a contribution by Dr. Reimold (**16**) describing the results obtained by several farmers at Rannstedt. The soil was loam, average rainfall 450 mm., mean annual temperature 8°C. The crop was sown in April in 25 to 30 cm. drills and manured as for summer wheat, but not manured after the first cut (although this is recommended in the seed-growers' directions). The best results were obtained after roots, when a fairly good third cut was taken ; after wheat only two cuts, the plants being 80 to 100 cm. high, were obtained. Drilled in rye, the crop was a failure. Growers complained of the unpalatability of the fodder and of a diminution of milk from cows fed on mallow. The general opinion of the district was entirely adverse to repeating the experiment.

This note provoked a large number of letters from farmers, describing experience which conflicted with or confirmed that of the Rannstedt growers. Several of these letters have been reproduced (**11**). Three give extremely adverse reports ; a fourth grower obtained a crop and used it, but found it inferior in every respect to the Sudan grass grown for purposes of comparison. Dr. Reimold, who set the ball rolling, writes again to communicate fresh evidence received from farmers, confirming his original adverse report. On the other hand, however, a writer from the vicinity of Heidelberg (altitude 100 m., mean annual temperature 10°C., rainfall approximately 700 mm.) found the crop satisfactory from both the cultural and nutritional standpoints, and is continuing to grow it. No deterioration in milk production was observed. From Duisburg also successful results are reported from two farms. Here again no adverse effect upon milk production or the fat content of the milk was determined, and the fodder value of the mallow was considered good. Soiderer from Lower Franconia gives a good account of the mallow as grown and used by him ; he considers it destined to be useful in supplementing other crops, for example, the second cut of red clover, which tends soon to become hard in the writer's district, and maize and sunflowers, which are more sensitive to autumnal cold than the mallow. It was fed to animals in a mixture with red clover or maize. When the mallow was used up and maize alone was fed to cows, milk production decreased. Peschel from Ullersdorf, Kreis Glatz, and Pagel from Pomerania report successful experiments, the first-named writer announcing his intention of doubling the area occupied by mallow in order to obtain further experience. Pagel has used it for intercropping with lucerne.

Official Trials in 1937

After the publication of this correspondence Dr. Fuchs, of the Reichsnährstand, summarized the results of the Reichsnährstand's 1937 trials (**4**). Approximately a hundred of these were conducted in all parts of the country, both Lampe's and Ackermann's varieties being employed. When grown as the principal crop, yields ranging from 200 to 1,000 dz. per hectare were obtained ; the maximum yield was obtained

" in spite of drought." One neighbourhood even reported a three-cut yield of 1,200 dz. per hectare. Plants 2 to 2.5 metres high were not rare. Information on the experiments in growing mallow under another crop is incomplete : in some cases yields of 225 dz. per hectare were obtained, in others the height of the plants is noted as being from 1.20 to 1.60 m. Grown as a stubble or catch crop, yields ranging from 60 to 590 dz. per hectare were obtained. These, in comparison with those obtained from other catch crops, are considered eminently satisfactory. Having briefly referred to the findings of scientists on nutritive value, Fuchs summarizes as follows: " The mallow exhibits uneven, poor shooting capacity. This disadvantage, according to a communication received in the meantime from Dr. Sessous, of Giessen, may be remedied by special treatment of the seed. Water requirements, especially during the early stages of the plant, are high. When, however, the mallow has once become established, it will tolerate periods of drought. On account of the plant's slow early development, mallow fields are easily invaded by weeds and much hoeing is necessary. Like all bulk-producing plants, the mallow requires ample manuring. When several cuts are taken, satisfactory yield can be obtained only by means of repeated doses of nitrogenous fertilizer. The soil must be in a good state of cultivation, as the mallow makes more use of the soil than any other plant. Sour soils are out of the question for mallow growing. A humid climate or ample soil moisture is requisite.

According to present information, yield is unreliable. In using the crop for fodder, care should be taken that the plant is not too old. Older plants should be chopped. These disadvantages are not peculiar to the mallow. . . . . That the mallow constitutes, however, a reliable and the cheapest source of home-grown protein, as is asserted by the breeders, has yet to be proved.

Failures are probably often attributable to incorrect technique, for example, sowing too deep, in drills that are too close, in poor, acid soil, etc. . . . . The trials have shown that the mallow, under certain conditions, is capable of producing considerable yields of fodder rich in protein. The best yields were obtained on humus soils that were not too dry. Very good yields were also obtained on the moor soils. Marked tendency to weed growth was, however, a complication here. Wherever there is a shortage of labour, the cultivation of mallows should not be attempted.

This much has been ascertained, namely, that the mallow can never replace lucerne. . . . . Wherever the soil permits the growing of lucerne, lucerne should be the principal crop. The mallow cannot be of importance as a catch crop or for sowing under another crop unless grown in soil in a good state of culture, in a locality with ample rainfall and unless carefully cultivated and adequately manured."

Experiments in Other Countries

Řechka reported in 1937 that *Malva verticillata* is under trial at the Agricultural Experiment Station, Liblice, Czechoslovakia, and at the Seed Testing Station, Brno (**15**). An obstacle to its cultivation in Czechoslovakia is the high price of the seed,

namely, 128 Kč per kg. Indigenous forage crops are not only cheaper, but also more palatable. A subsequent report by Svoboda and Řechka gives a preliminary account of the Liblice trials (**20**). The yields obtained were as follows (green weight in quintals* per hectare) : before flowering, 360 ; in full bloom, 454 ; after flowering, 462. Nutrient content at four stages of the plant has been studied. At the beginning of the flowering period the digestible protein content was 1.60 per cent, or somewhat less than that of lucerne. The mallow proved palatable to dairy cows. The effect upon milk production and on the fat content of the milk is being studied. Praxa (**13**) notes its protein value, and Heinisch (**7**) mentions it among other plants discussed for their value as substitutes for wheat, sugar beet and hops, to the growing of which in Czechoslovakia limits have been legally imposed.

In Russia Močalov (**12**) has drawn attention to the value of the mallow as a fodder plant, ranking its nutritive value equal to that of lucerne or sainfoin. He notes that it should not be fed to animals that are fasting.

Postscript. Since the above review went to press an article has been published by F. Berkner and H. Nietsch, Plant Breeding Institute of the University of Breslau, on the physiology of nutrition in Lampe's fodder mallow (*Pflanzenbau*. 14. 321-43. 1938). These authors have studied the uptake of nutrients from the soil and the formation of nutrients in *Malva verticillata* as compared with several other forage plants. The findings of previous workers concerning the high water, warmth, and nutrient requirements of the mallow are confirmed. In total performance it was found to be inferior to the other forage plants tested, but it is considered that it might be useful as a catch crop, sown under another crop, under suitable climatic conditions. A more detailed article on the subject is to be published shortly by the above-mentioned Institute.

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* 1 quintal = 100 kg.

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VARIATION WITHIN STRAINS IN NORWEGIAN RED CLOVER

[Reviewer: R. Peter Jones]

A survey of the variation in some morphological and physiological characters in Norwegian late clover and in some material of wild red clover is given by H. Wexelsen of Vidarshov, Vang, Hedemark, Norway in *Tidsskr. norske Landbr.** The cultivated strains included were Molstad, Toten, Leinum, Fosnes, Hove and Bråtå. The wild clovers included were: Foss, from Valdres; Løken, from Valdres; Etnestølen, from Etnestølen, 900 metres above sea-level; Sikkilsdal, from Sikkilsdal, Jotunheimen; Røros, from Røros; Inderøi, from Inderøi, N. Trøndelag; Vidarshov, from Vidarshov, Vang, Hedemark.

Much of the clover found growing wild is really cultivated clover and the author has often received samples labelled "Wild clover" which proved on investigation to be cultivated late clover. During the flowering period wild clover is strikingly different from Norwegian late clover, and if the habitats are examined in June pure populations of wild clover can easily be found. Judging by earliness and type the populations examined by the author were fairly pure wild clover populations; the most typical wild clovers were Etnestølen and Røros, that is, the clover from the most elevated and remote habitats. In the other red clover lots there were a few plants which were suggestive of cultivated clover in many characters; they were later more vigorous, more erect and leafy and so on. These were labelled cultivated clover ? or hybrid ?. It is not precluded that such types lie within the limits of variation in genuine wild clover, but the author considers it most probable that they are admixtures or rather hybrids between cultivated and wild clover. In addition to the wild clover material referred to in this paper, the author subsequently collected and planted out in the field wild clover from a series of localities in south Norway. All the plants were early and belonged to the type he considered to be genuine wild clover. In more southerly countries late types of wild clover occur, but in any case as far as south-east Norway is concerned, he is inclined to regard late types of wild-growing clover as cultivated clover or hybrids.

The seed of the clover to be investigated was sown in April in sterilized soil in pots. The young seedlings were pricked out in boxes and planted out as single plants at a distance of 50 × 60 cm. The number of plants was counted each spring and autumn and descriptive notes were made on two occasions in the course of the growing period.

Growth Type

This is a very striking character with marked variation even in the tuft stage

*Undersøkelser over norsk rødkløver. Variasjonen innenfor stammene. [Investigations on Norwegian red clover. Variation within strains.] *Tidsskr. norske Landbr.* 44. 135-49. 1937.

Editor's Note: The article under review was continued in No. 6, pp. 161-83 of the same journal. The second part, which contains an English summary, gives results of a study of characters such as leafiness, chemical content, persistence, flowering time, etc. A short review of the second part will be given in the September issue of *Herbage Reviews*.

and in the fully grown stage. In Figure 1* to the left is shown an erect tuft type, to the right a prostrate tuft type. The quite flat prostrate tuft type occurs particularly in wild red clover (Fig. 8.) When this type is leafy, which it rarely is in wild clover, it gives the impression of being a pasture type, but the question as to whether it has any value as a pasture plant has not yet been investigated.

Another outstanding character in the tuft stage is the development of the radical leaves. Early cultivated clover forms in the seeding year a weak leaf-rosette or no rosette at all, but develops stems and flowers. Late clover forms a strong tuft and generally does not put forth stems. In this character, however, there is great variation, and in Norwegian late clover many plants of the same type as early clover occur. Wild clover resembles late cultivated clover in that it does not develop stems and flowers in the seeding year in spite of the fact that it is early. Early wild clover in Norway and early cultivated clover which derives from more southerly regions have in the main only earliness in common; in most other characters the two races are in the highest degree dissimilar.

Tuft development, stem shooting and flowering in the first year are undoubtedly very dependent on environmental factors, particularly on the time of planting or sowing. Probably it is a question here of a reaction to the length of day. That hereditary differences occur in these characters in Norwegian late clover is undoubted. This is particularly striking when plants have been put out early to expedite flowering the first year. Some of the plants will then put forth a number of stems and flowers in August-September without developing any leaf rosettes, others will develop a weak rosette and form some stems, while others again will develop a vigorous leaf rosette, without a trace of stems. In the autumn of 1934 there were very clearly marked differences in this respect. In Figure 2 are shown two sister plants which had grown in the field side by side, the one with a weak leaf rosette and a large number of stems, the other with a strong rosette and no trace of stems. In Figure 3 are seen two sister plants from a cross between two types of wild red clover of the same type as the plant on the right, an ascending plant with a weak rosette of radical leaves. Approximately one-quarter were of the same type as the plant on the left, an abnormal development of radical leaves with very weak stem development. In the statement below are given some figures based on classification with regard to the development of radical leaf rosettes:

	With	Without		With	Without		With	Without
A109	61	61	A 91	6	25	A 88	101	28
A 87	39	24	A 98	18	107	A105	43	14
A 89	27	18	A100	40	124		—	—
A104	20	42		—	—	Total	144	42
A 97	43	54	Total	64	256			
	—	—						
Total	190	199						

The families differ somewhat in the number with and without leaf rosettes; the

*Figures are not reproduced in this review. Investigators interested should consult the original journal, or request a reprint from the author.—R.O.W.

same applies to the development of stems and flowers where a grading into 3 classes was carried out.

The author had expected that there would have been a connexion between these two characters and overwintering capacity, as early cultivated clover with weak leaf rosettes is not hardy in Norway. But in this material there did not appear to be any such connexion. The overwintering percentages for the winters 1934-35 and 1935-36 were approximately the same in the families irrespective of the percentage of plants with leaf rosettes and the percentage of flowering plants. The question needs further investigation, but the author's observations of this material indicate that there is no correlation between the type the first year and overwintering in late clover or that generally other factors are more decisive.

On the other hand his experience has been that plants which have poor tuft development as a consequence of late planting are less winterhardy.

L. P. Bordakov found that rosette-type in lucerne was a very important character which was connected with the power of resistance to frost and drought. Races with prostrate tuft type were more winterhardy than those with erect tuft type. In red clover the wild type has a more prostrate tuft than cultivated late clover. Wild clover appears also to be slightly more tolerant of low temperatures than hardy late clover, but in single plant fields wild clover has not been more persistent than cultivated clover. The author does not know whether there is any connexion between tuft form and tolerance of frost. He has not been able to demonstrate such a correlation within late clover, but it is for the rest very difficult to establish even if it exists. He has no populations which are homogeneous for the one tuft type or the other. He has bred families which are homogeneous but then inbreeding was practised which reduces vigour of growth and probably overwintering capacity.

At the beginning of flowering the plants were divided into four classes according to growth type : prostrate (Figure 4) the stems lie along the ground, only the uppermost part is raised, completely flat, prostrate types occur in wild clover. Class 2 is ascending, the stems extend first to the side and curve upwards (Figures 5 and 9). Class 3, *widely erect* (Figure 6) and class 4, *extremely erect*, an extremely erect, compact type (Figure 7). There are, of course, no sharply defined limits between these classes, but they are main types well adapted to exhibit the variation in the character. Table 1 shows a classification of wild and cultivated clover into these four groups. In cultivated clover the numbers in the classes erect and ascending are approximately equal, together slightly above 95 per cent. In the extreme classes there are only 7 and 8 individuals out of 302. Wild clover has a less erect type of growth, the majority of the plants are prostrate or ascending. Etnestølen and Røros in particular were prostrate types. The one extremely erect plant in Løken wild clover is probably an admixture, or hybrid ; this type hardly ever occurs in genuine wild clover.

Bråtå clover is a cultivated early clover from Skjåk, Gudbrandsdalen ; it is placed by itself as in most characters it occupies an intermediate position between cultivated and wild clover. Through selection families have been obtained which are fairly constant for different growth types, which shows that in clover strains there is

Table 1.—Growth types in cultivated and wild Norwegian red clover.

Strain	Number of plants with growth type				Total number of plants
	Creeping	Ascending	Erect	Extremely Erect	
Cultivated clover					
Molstad	5	68	63	5	141
Toten	—	33	33	1	67
Leinum	—	25	30	2	57
Fosnes	1	10	17	—	28
Hove	1	6	2	—	9
Total cultivated clover	7	142	145	8	302
Per cent	2.32	47.02	48.01	2.65	100.—
Bråtå	12	90	20		122
Per cent	9.84	73.77	16.39		100.—
Wild red clover					
Foss	7	20	—	—	27
Løken	17	77	9	1	104
Sikkilsdal	41	90	5	—	136
Etnestølen	24	97	2	—	123
Røros	22	29	2	—	53
Inderøi	10	48	—	—	58
Vidarshov	26	22	2	—	50
Total wild red clover	147	383	20	1	551
Per cent	26.68	69.51	3.63	0.18	100.—

a strong hereditary variation in this character. But little is known of the hereditary basis of types. In crosses between prostrate wild clover and erect cultivated clover the F_1 progenies were intermediate.

Tillering

Tillering—the number of stems—is another outstanding character. There exist slender types with few stems, and others with a mass of stems (Figure 6). In Table 2 is shown a grading into five classes of wild and cultivated clover in regard to tillering. Cultivated clover has about the same number of individuals in the three classes high, medium, small, and six individuals in the class very high. In wild clover, tillering is very much weaker. Many plants are of the type shown in Figure 9, but there are too a few types with luxuriant stem development.

Table 2.—Tillering in cultivated and wild Norwegian red clover.

Strain	Number of plants with degree of tillering					Total number of plants
	Very high	High	Medium	Small	Very small	
Cultivated clover						
Molstad	2	24	22	13	—	61
Toten	1	30	25	14	—	70
Leinum	2	11	19	25	—	57
Fosnes	1	7	7	13	1	29
Hove	—	2	—	7	—	9
Total cultivated clover	6	74	73	72	1	226
Per cent	2.65	32.74	32.30	31.86	0.45	100.—
Bråtå	—	7	33	32	2	74
Per cent		9.46	44.60	43.24	2.70	100.—
Wild clover						
Løken	—	14	21	47	—	82
Foss	—	1	6	20	—	27
Sikkilsdal	—	11	27	41	7	86
Røros	—	—	4	21	—	25
Inderøi	—	1	12	22	1	36
Vidarshov	—	6	7	21	—	34
Total wild clover	—	33	77	172	8	290
Per cent	—	11.38	26.55	59.31	2.76	100.—

To compare families of red clover the author conducted trials with plants in rows, ten plants in each row, the distance between the plants being 25 cm. and between the rows 50 cm. There were four parallels of each family and Molstad was grown as a check in every sixth row. In these trials the number of stems on each plant was counted.

To reduce the tabulated material in printing it has been necessary to omit tables showing variation within families and differences in their range of variation. The number of stems varies in Molstad from less than 10 to 106 with an average of 37.37. In five families in the same field the average figures were as follows :

A29 – 1 – 3	21.69
78 – 1 – 3 – 1 – 1 – 3	50.74
F20 – 1	50.63
F26	61.21
6 – 1f – 0 – a0 – 1	61.41

Selection has thus produced families with considerably stronger tillering than the mother strain. In these trials the weight of individual plants was also determined, and there was found to be a close connexion between tillering and weight. It is not known whether this is so in a dense stand of clover, but the weakly tillering types are certainly not sufficiently aggressive and productive and should be eliminated. If the clover has become thin the strongly tillering types will be able to utilize the space and cover the ground best.

Plant height

The variation in plant height in individual plants of a strain grown the same distance apart under conditions as similar as possible is very considerable. A great part of this variation is not hereditary and is due to a series of environmental factors, germinating power of the seed, conditions of germination, soil variation and other varying conditions of growth. But still there is no doubt that considerable hereditary variations in plant height occur within clover strains. In Table 3 is given a classification for plant height in cultivated and wild clover. It is obvious that the height of the plants is much greater in cultivated clover than in wild clover. It should be emphasized here that wild clover during cultivation as single plants in good soil fully preserves its " wild type" which is hereditarily conditioned, although it may be slightly more vigorous than in the natural, often somewhat dry habitats. Owing to its weak tillering and lack of height it is certainly not sufficiently productive as a hay plant in Norwegian meadows. In the trials in which the number of stems was counted, measurements of height of individual plants in a large number of families were also taken. The variation was considerable. In field CVI 1935 the height in Molstad varied from 75 to 125 cm., with an average of 94.95 cm. The shortest family had an average of 47.98 cm. and the tallest an average of 109.19 cm. Plant height is strongly influenced by inbreeding.

Table 3.—Plant height in cultivated and wild Norwegian red clover.

Strain	Number of plants with plant height				Total number of plants
	Large	Medium	Small	Very small	
Cultivated clover					
Molstad	14	32	10	—	56
Toten	3	51	19	—	73
Leinum	4	33	22	—	59
Fosnes	7	18	4	—	29
Total cultivated clover	28	134	55	—	217
Per cent	12.90	61.75	25.34	—	99.99
Bråtå	—	29	44	1	74
Per cent	—	39.19	59.45	1.35	99.99
Wild clover					
Løken	—	22	57	1	80
Foss	—	4	20	3	27
Sikkilsdal	—	9	78	3	90
Røros	—	—	24	—	24
Inderøi	—	1	35	—	36
Vidarshov	—	5	31	—	36
Etnestølen	—	—	27	—	27
Total wild clover	—	41	272	7	320
Per cent	—	12.81	85.—	2.19	100.—

Number of internodes

In the same trials the number of internodes was counted and Table 4 shows the variation within Molstad and some families with dissimilar internode length. Molstad has on the average 7.77 cm., the average for the families varies from 4.91 to 8.24 cm. This character too is influenced by inbreeding.

Table 4.—Number of internodes in families of red clover.

	Number of plants with number of internodes							Total number of plants	Mean
	4	5	6	7	8	9	10		
Field CVI 1935.									
Molstad		2	12	33	28	21		96	7.77
A24—3—1—1	4	11	4					19	4.91
A29—1—3	10	10	6	1				27	4.98
15—1—0—1—3			2	2	18	6		28	8.00
C—IV				4	14	10	2	30	8.24

Vigour of growth. Individual plant weight

Plant height and tillering are the two most important factors which determine the weight of the individual plant when it is grown spaced out and without competition. Plant weight will then of course be even more variable than height and tillering. It is influenced still more strongly by environmental factors and by inbreeding. In Table 5 is shown the variation in vigour of growth (individual plant weight) in Molstad and some families from field C III 1932. The weight of Molstad plants varies from less than 50 grm. to between 600 and 650 grm. The average in the families varies from 215 to 519 grm.

Table 5.—Variation in vigour of growth in families of red clover.

Number of plants with fresh weight in grm.	Family Field C III 1932						
	Molstad	9–1–3–1	9–1–1–20	15–1–0–1	51–1–0–1	86–1–2–1	XXVI
— 50	2	1		2			
51—100	3	1	1	1	2	2	
101—150	4	5	6	1			
151—200	5	4	4		1		
201—250	6	4	5	1	4	2	1
251—300	5	5	3	3	3	3	1
301—350	1		8	2	4	3	
351—400	4	4	5	4	1	4	4
401—450	5		1	3	5	5	2
451—500	7		2	8	6	5	2
501—550	4			3	1	4	3
551—600	1			7	2	1	4
601—650	3			2	2	1	3
651—700				1	3	5	3
701—750				1	2	2	
751—800						1	1
801—850					1	1	
851—900				1			
901—950	1						
Total number of plants	51	24	35	40	37	39	24
Mean grm.	344.2	215	272.7	425.2	435.9	485.4	519

THE WORKS OF V. N. LJUBIMENKO

Obituary by I. Znamenskiĭ

Presented by the Academy of Science of U.S.S.R., Moscow, U.S.S.R.

[Translated from Russian]

On September 14, 1937, Vladimir Nikolaevič Ljubimenko, Corresponding Member of the Academy of Science of U.S.S.R., Member of the Academy of Science of Ukrainian S.S.R., and Director of the Experimental Botany Department of Botanic Research Institute at the Academy of Science of U.S.S.R., died of heart failure in Leningrad. With his death Soviet and world science lost an illustrious worker with a comprehensive knowledge of botany and biology, whose high authority in questions of aerial nutrition and pigments of plastids is universally acknowledged.

Ljubimenko was born on January 18, 1873, in the former Voronezh province. His early education he received at home, later at the Primary Town School, and then at the Agricultural School in Kharkov. In 1894 he entered the Institute of Forestry in St. Petersburg, completing his training there in 1898 with distinction, a gold medal being awarded for his research on " The precipitation of crystals of acid potassium oxalate in the floral organs."* At the conclusion of his training he was granted a stipendiary for training in Professorship by the Institute Council. In 1902 Ljubimenko completed his study in the Physico-Mathematical Faculty of St. Petersburg University. From 1903 he made several journeys abroad. First to Bonn for research in cytology under Professor Strasburger, where he carried out research on a division of the nuclei of pollen mother cells and embryo sacs in Nymphaeaceae. In 1904 he was sent by the Council of the Forestry Institute to Paris for research under Professor Bonnier of the Sorbonne. It was here that he began to investigate photosynthesis in light-loving and shade-enduring woody plants. In a continuation of this study he was again sent to France and Germany in 1905. In 1912 he succeeded to a special scholarship at the Academy of Science, granted to botanists and zoologists for educational travels in the tropics. In 1913 Ljubimenko travelled to Australia and the Malayan Archipelago (Celebes, Java and Sumatra), where he investigated chlorophyll content in tropical plants. In 1923 he was sent by the Academy of Science to Paris to attend the *Congrès international pour la protection de la nature, faune et flore, sites et monuments naturels*, where he gave a report on the reserves in the U.S.S.R. In 1926 he was delegated by the Academy of Science to attend the Fourth International Botanical Congress, Ithaca, N.Y., where he gave a report on the " Chlorophyll and the genesis of the photosynthetic mechanism of plants." In 1924 Ljubimenko was elected a member of the American Phytophysiological Society ; in 1929 a member of the American Genetic Association ; and in 1935 a corresponding member of the American Society of Plant Physiologists, and a member of the Linnaeus Society at Lyons.

*A complete list of works published by Dr. V. N. Ljubimenko will be given in a later issue of *Herbage Reviews*.

In 1910 Ljubimenko presented his dissertation on " The chlorophyll content in chromoplasts and the energy of photosynthesis" and graduated in the degree of Magister ; in 1917 he obtained the Doctor's degree for his research on " The transformation of the pigments of plastids in the living tissues of the leaf."

In 1922 Ljubimenko was elected corresponding member of the Academy of Science of U.S.S.R., and in 1929 a member of the Academy of Science of Ukraine. Until his death he was in charge of the Experimental Botany Department of the Botanical Institute of the Academy of Science of U.S.S.R.

In a brief obituary it is impossible to present, even in a condensed form, a review of his comprehensive and many sided scientific life, for during his fruitful 40 years of experimental and literary life he published over 200 papers and books. Even cursory acquaintance with his scientific work will reveal the wide range of the subjects touched upon by him, while a closer knowledge would exhibit a harmonious blending of the depth and comprehension in studying a particular problem, as well as a very methodical and planned approach to the elaboration of every item.

His scientific work was concerned with the following main problems :

(1) *Pigments of plastids and the physiology of plastids*, to which he devoted 44 published papers, his dissertation on " The transformation of pigments of plastids in living tissues of plants," being the most comprehensive investigation on this subject. By elaborating the study of pigments in more and more detail, extending the method of this study, enlightening the experimental and observation data with new ideas and generalizations, Ljubimenko gave a new conception to pigments in the plant kingdom.

(2) *Photosynthesis and the accumulation of dry matter*, to which he devoted 33 published papers. The centre of this cycle of research lies in the elucidation of the adaptability of light-loving and shade-enduring plants through the plastid mechanism, namely, through the concentration of chlorophyll ; on the discovery of the relation between the energy of gaseous exchange and chlorophyll content ; on the establishment of specific differences in the utilization of red and blue rays for photosynthesis among light-loving and shade-enduring plants, and on the discovery of the adapability of light intensity of the plastid mechanism in seaweeds of different colours and from different depths. The latest synopsis on " Phytosynthesis and chemosynthesis" (1935) represents the accomplishment of research on this problem.

(3) *Physiology of individual development of higher plants*, in particular questions relating to photoperiodism (10 published papers), research on which was begun in 1922 in collaboration with Mme O. A. Ščeglova and continued until his death.

In addition to these three main items which were at the centre of his studies, Ljubimenko gave much attention to the specific effect of light on the assimilation of elaborated organic matter (17 publications), the physiological conditions of the elaboration and accumulation of ethereal oils and alkaloids (6 publications), and then to the analysis of the adaptive process in plants (9 publications, including a book on biology of plants published in 1934) ; this book is an interesting and original synopsis to the preparation of a revised and completed edition of which he devoted the last

year of his life. Finally, numerous publications were devoted to miscellaneous physiological problems.

His ability as an inventor and constructor enabled him to design several original scientific instruments, of which the best known is the spectrocolorimeter, first constructed conjointly with N. A. Montévérdé and later much improved by himself alone.

He gave much of his time and attention to the training of young scientists, sharing with scientific beginners his knowledge and experience, passing on that adhesion to discipline and steadiness in work with which he was so greatly endowed himself, and cultivating in them a critical approach to the literature and their own experimental data.

A good deal of his time was take up by work of an applied character and he was the author of a number of contributions on tobacco, medicinal and other plants, as well as the Editor-in-Chief of comprehensive handbooks on " Plant raw materials of U.S.S.R." and on " Weeds of U.S.S.R."

Ljubimenko acted as a teacher in the High Schools of the Union from 1902 until 1920, when he was compelled to abandon this work for health reasons. Many years of lecturing experience was embodied in his "Course of general botany" (1923), reissued later (1927) in a revised form in French.

In addition to his energetic scientific and teaching activities, V. N. Ljubimenko was also active in public life. There was not a single botanical meeting or conference in which he would fail to take an active part as an organizer or reporter. He frequently lectured before workers and Red Army audiences and during the latter years held colloquia with school teachers.

Ljubimenko reckoned the interests of scientists above all and yet at the same time was not a narrow specialist. With his gifted nature he was interested in all avenues of life ; he was devoted to music, theatre, literature and sport, he played the violin and was a good artist. After the October Socialist Revolution he took a great interest in political and economic questions, read widely upon the subject and attended lectures at the Marx-Lenin University. He never failed to admire the achievements of his socialistic country in all directions and particularly in the growth of culture and science.

With the premature close of a life so fully gifted, Soviet and World science has lost a man well and broadly versed ; one of the leading plant physiologists ; a talented and energetic investigator ; an excellent lecturer ; and a man with a sympathetic understanding towards his fellow men.

A STUDY IN VEGETATIVE REPRODUCTION

Vegetative reproduction as a method of maintaining stock in a homozygous state is also widely used in work with plants which cannot be described as capable of reproducing themselves vegetatively in situ ; in fact almost all cultivated plants are known to possess the faculty of vegetative reproduction. The cause for this ap-

parently lies in the character of cell differentiation which begins in plants, not at an early embryonic phase as in animals, but progressively with growth and development, a totipotent meristem (one capable of developing into or generating a complete organism) being found on the plant body throughout its lifetime. Irrespective of the method, vegetative reproduction is effected through cell division and differentiation of somatic cells. Consequently the clones retain all the individualism of the mother plant no matter how heterozygous it might be. Nevertheless, somatic mutations and modifications are known to be particularly frequent in vegetative reproduction, a fact which is of importance in breeding plants, although not because they may lead to the building up of new strains (such cases have not yet been reported). Below are described three methods of vegetative reproduction of which the third deserves particular notice not only as a method inducing somatic mutations or modifications, but chiefly as a study revealing one of the factors which increases their frequency, namely, showing up the importance of breaking the relationship between the new plantlets and the mother plant.

Three methods of vegetative reproduction were tested with wheat plants by S. A. Pogosjan* of the Institute of Plant Breeding and Genetics, Odessa.

With the first method the stems of earing plants were bent over close to a well manured and moist soil. In 20 days most of the nodes produced rooted shoots. Later the bent stems began to die off and the nodal shoots began to live independently of the mother plants. About 200 plantlets could be obtained from one plant by this method.

With the second method the nodes of the main stems were wrapped in blotting paper submerged in a tube containing a complete nutrient solution. Within 10 to 15 days rooted shoots sprang from these nodes. The newly formed shoots were maintained thus on a double nutrition, one through their own roots and the other from the mother plant.

With the third method the shoots obtained by the second method were carefully removed from the mother stem, planted in moist sand and later transplanted into the soil. With intensive nutrition and without injuring the mother plant in removing the nodal shoots plantlets can be obtained repeatedly from one and the same node.

The results of a comparison of the morphology of the clones obtained by these methods were interesting. The clones obtained by the first two methods differed but little one from another, or from the mother plant. Nevertheless, the shoots from the upper nodes had two or three nodes at the time of earing and those from the lower node had four or five nodes. It was different with the clones of the third group which were separated from the mother plants at an early phenological phase (the second or third leaf) and grown exclusively on their own roots. The clones from the same mother plant showed conspicuous morphological differences exceeding the limits of possible fluctuation of the mother plants. All had, however, four or five nodes.

*S. A. Pogosjan, 'Obtaining lateral stems from the nodes of the main stem of wheat.' *Jarovizacija* 5 (14), 1937, pp. 72-7.

The formation of plantlets differing between themselves and also from the mother plant not only in time of flowering, as was apparently the case with the first two methods, but also in a number of other characters, as with the third method, a phenomenon which H. Molisch described in 1922 as topophysis, is usually traced to the situation of the plantlets along the stem of the mother plant and to the phenological state of the mother plant as a whole. T. D. Lysenko in 1932 gave a different interpretation based upon the phasic development (differentiation) of the tissues, forming the shoots. The changes pertaining to the advance of a plant towards reproduction are effected, localized and retained in the promeristematic cells and are transmitted thence only through cell division. Consequently the upper and later formed tissues are more advanced in development than the lower earlier formed tissues that is, the tissues along the stem are variously differentiated and hence the shoots arising from them are qualitatively different. However, as Pogosjan's test showed, the topophysis was intensified when the effect of the mother plant was discontinued at an early developmental phase of the nodal plantlet. This relation between the mode of differentiation of somatic cells of plantlets and the mother plant certainly deserves closer study, but no parallelism should be sought, as apparently the author tends between these somatic mutations or modifications and the mutations obtained by Lysenko in " training" of plants as a result of the fusion of germ cells.

A RUSSIAN TEXTBOOK ON PLANT ECOLOGY

THE lectures given by Dr. G. I. Poplavskaja, Dozent of the State University of Leningrad, during the five year period 1930-1935 at the Biological Faculty of that University have been published in the form of a book, under the title of " An abridged course in plant ecology."*

Ecology is one of the most recent branches of biology ; in fact the very name was first invented by Haeckel in 1866 to cover the relationship of animals to their environment. The scope of ecology has not yet been rigidly agreed upon, some ecologists extending it to cover the study of plant associations (phytocoenosis), that is, physiographical ecology or phytocoenology, while others restrict ecology to a study of the relation of individuals to the environment. Although this disagreement will not be considered here, it may be said that the desire to discriminate between the two is not altogether unfounded, as they have indeed different aims, the one studying the relation and development of an entire interrelated group of plants from the environmental aspect, and the other the relation of the individual plant to its habitat. The author, presumably together with most Russian ecologists, discriminates between these two aspects of the environmental study, defining the former as synecology, and the latter as autecology, and aims to cover the latter in her book. It is for this reason

*POPLAVSKAJA, G. I. [Abridged course of plant ecology.] Ogiz-Biomedgiz, Leningrad, 1937. pp. 298. 152 figs.

that in the ninth chapter (pp. 256-9) dealing with the biotic factors, only micro- and macro-fauna and anthropogenic effects are considered, the interrelation between plants having been omitted as a phytocoenological subject.

Accordingly the author first introduces the general conceptions of environment and the environmental factors, and their ecological significance separately and then together in their complex action upon the plant and its adaptation to them.

In the introductory chapter (pp. 7-19) an attempt is made to include the ecological conceptions of Lysenko's school, namely, " the conditions of the habitat," a geographical conception, are discriminated from " the conditions for existence," understanding by the latter those environmental factors without which a plant cannot exist, or at least progress towards reproduction, its ultimate goal. Such a specification of environmental factors does not, of course, eliminate the conception of the so-called direct and indirect factors, but defines either as regards the plant and its advance in development.

The ecological significance of water is examined in great detail in the first chapter, which covers about one-half of the book (pp. 21-142). The greater part of this chapter is devoted to the ecological principles of the subdivision of plants into aquatic (hydathophytes and hydrophytes) and land plants (hygrophytes, mesophytes and xerophytes) and also into oxylophytes (the plants of sphagnum bogs), psychrophytes (arctic plants) and alpine plants ; the last three categories are treated separately in view of the special features of their habitat. This discussion is prefaced by an account of the difference between the air medium and the water medium and the ecological effect of various forms of water in nature. It has been established that the perishing of plants under an ice crust is due on the one hand to the aerobiosis formed beneath it, and on the other hand to the accumulation of ethyl alcohol in the plant tissues. In addition, freezing of water in the upper layers of the soil causes upward currents of soil water which move the seeds and roots towards the surface, thus exposing them to frost and causing mechanical injury.

The ecological effect of soil water is examined in detail with special reference to " physiological drought," that is, disturbance in the balance between the amount of water physiologically available to the plants, and their rate of transpiration which largely depends upon the temperature gradient between the soil and the air. Xerophytism or rather resistance of plants to drought is also explored in detail ; it is not solely related to the size of stomata ; there is no direct correlation with transpiration ; it depends upon many other anatomical, morphological and physiological characters which reduce transpiration, as well as upon the resistance of protoplasm to dehydration and the faculties of plants to recover rapidly after a period of soil drought. In addition, the resistance of plants varies with their developmental phase. On the whole, resistance to soil drought is a very complex problem which still requires much study. Even less is known about the ecological effect of air drought, which by reducing the rate of transpiration leaves its impress upon the anatomy and morphology of the leaves.

The new ecological principles have left a deeper mark in the second chapter

(pp. 143-70) dealing with thermal factors, namely, the cardinal* temperatures for the advance of a plant in development vary with the type of plant and the developmental status of its organs. In some coniferous trees, such as *Larix* and *Abies*, the vegetative shoot grows best at 7 to 10°C. and the roots at 5 to 6°C., while higher temperatures are required for flowering; on the contrary, in *Alnus*, *Betula* and *Salix* flowering occurs at temperatures lower than those which maintain growth of the vegetative shoots. Again, cereal plants require lower temperatures at the beginning of their development than at the end, while cotton plants show a reverse relation to temperatures. Furthermore, the conception of critical temperatures must also be modified. Whatever may be the physiological cause of the lethal effect of low temperatures, the endurance and consequently "the critical temperature minimum" vary with the advance of a plant in development, and depend largely upon previous weather conditions which may and usually do, as in the autumn, harden the plants to low temperatures. The ability of a plant to harden (acquired resistance) has been proved to be of greater importance than its initial (inherited) resistance as such, and this ability varies also with advance in development.

The ecological significance of high temperatures has not been adequately investigated, but undoubtedly their effect must be studied with reference to the plant and the developmental status of its organs. At the present time the opinion that the effect of high temperatures on plants during dormancy (bulbs, tubers and roots) is negligible has been challenged in the light of Lysenko's investigations, which indicate a lower vitality in potato plants grown from tubers which had been formed and developed at high temperatures. Not without interest is the experimental evidence of the formative effect of temperatures; with an increase of temperature during vegetation the leaf-blades of *Taraxacum* change from strongly dissected to almost entire.

The ecological conceptions introduced by Lysenko compel us to revise the conception of the adaptability of plants to temperature (and indeed to any other potent factor) and their subdivision in respect of cardinal temperatures. The existing classifications disregard the changes in the relation of plants to temperature and are based almost exclusively upon daily means without recording daily variation of temperature. On the whole the adaptation of a plant to climatic factors consists in the shifting of its cardinal points of temperature, light and other ecological factors (conditions of existence) at which its development may progress.

One of the potent factors is the temperature of the soil affecting the status of the roots and the thermal gradient between the air and the soil. The experimental evidence shows that the optimal gradients vary with the plant and its advance in development. More recent investigations indicate that subterranean ice (permanent frost) has an indirect effect, preventing the penetration of roots into the neighbourhood of the freezing region and promoting deformation of the surface and the accumulation of water in the upper soil layers.

The second chapter concludes with a brief review of the vernalization of agricul-

*Optimum and upper and lower limits.

tural plants introduced, however, with a misleading, if not erroneous definition of vernalization as a method accelerating the development of plants towards reproduction.

In the third chapter (pp. 171-97) light is examined as an ecological factor affecting photosynthesis, transpiration, growth rate and the physiological and anatomo-morphological features of plants. The usual classification of plants into heliophytes and sciophytes is extended by introducing a category of shade-enduring plants. The cardinal points are, however, still less rigid than the cardinal temperature and are even more dependent upon the developmental status of the plant. Consequently, the relation of plants to light (photoperiodism and the photoperiodic adaptation) as a factor affecting the development of plants is particularly important. Here again the new ecological principles have modified the previous conceptions to the effect that plants require no photoperiods whatever, but light (long-day plants) or darkness (short-day plants) and not for their entire reproductive development, but only for a definite part of it (the photophase) after which they usually change in their relationship to light conditions and the cardinal points.

The new principles are largely concerned with some of the conceptions held in plant phenology, which are critically reviewed in the fifth chapter (pp. 201-12). The delay in flowering northwards and with increasing elevation may be true only for some plants. The method of the isophene which perforce cannot account for the racial composition of a species and the details of the habitat is too crude to be of any value in ecology. The sum of useful temperatures is meaningless ; it does not include the daily variations of temperature and their effect on the plants ; both high and low temperatures may be " useful " at one developmental phase and " useless " at others. It fails to account for spring flowering plants, such as *Eriophorum*. The onset of flowering or any other phenological phase is not merely the result of the accumulation of useful temperatures or of the action of a climatic factor, but is brought about as a result of the response of a plant to the complex periodicity in the sequence of all the climatic factors of the habitat. Phenologists should, therefore, study not the effect of a single factor, but the effect of all the ecological factors forming the environment in its minutest detail. The conception of the " climate of wheat " or the " climate of cotton " is indeed more sound, as it accounts for all the meteorological factors and their complex effect upon the development and yield of a plant. The complex effect of climatic factors and ecological belts are dealt with in general terms in the sixth chapter (pp. 213-6).

The ecological significance of edaphic factors is discussed in the seventh chapter (pp. 217-52), the chemical and physical properties of the soil being dealt with separately. Either group of edaphic factors may act as direct and indirect ecological factors and their effect cannot be studied separately, since they act not only concurrently, but also as parts of a definite complex of mutual compensating and modifying factors. Most of this chapter deals with the differences between various edaphic types of plants.

The mechanical effect of wind upon plants and upon their transpiration, the

indirect effect of topography (elevation) of the habitat and the biotic factors are briefly discussed in the fourth (pp. 198-200), eighth (pp. 253-5), and ninth (pp. 256-9) chapters respectively.

The tenth chapter (pp. 260-4) is devoted to conceptions of "life forms," which are apparently not very popular among Russian ecologists, who consider that they are "inconsistent and stress only some of the ecological features of a plant." Ecotypology is dealt with in the eleventh chapter (pp. 265-74). Three categories are recognized, namely, climatypes, edaphotypes and biototypes, the last including coenotypes and pasture types. The ecotypes (hereditary differences) are discriminated from ecadic forms, that is, physiological and morphological modifications due to the habitat. In the twelfth and last chapter (pp. 273-5) the induction of new plants is examined as an ecological problem. Naturalization is defined as the transfer of a plant into a new but analogous environment. The acclimatization of individuals (the modification of individual plants) is discriminated from acclimatization of species (the result of natural selection of biotypes).

The text is supplemented with a subject index and an index of Latin and Russian names of plants; the latter two indexes are made up independently and hence unfortunately cross-references cannot always readily be made.

Without claiming an exhaustive survey of the comprehensive material now accumulated in plant ecology and omitting those details which would obscure the clarity of the fundamentals of the science to-day, the author has made a successful attempt to bring together and embody in a relatively short book all the essentials required for the student, for whom the book was intended. Dealing with the practical aspects to a greater extent than in any book on this subject, referring whenever possible to the native flora and experience, the author has produced a useful handbook for readers concerned with agronomy and forestry. The publication is of no less interest for the reader outside the author's country, as a comprehensive survey of the Russian literature (216 Russian titles and 84 foreign titles), the information from which is so rarely available outside the Soviet Union and is yet in such demand.—M.A.O.

FUTURE OF THE GREAT PLAINS

[Reviewer: R. O. Whyte]

The publication entitled, "The Future of the Great Plains"* represents the report of the Great Plains Committee as transmitted by the President of the United States to the First Session of the 75th Congress. From the following quotation from the President's letter of transmittal, it will be evident the conclusions to be drawn from

*United States, House of Representatives. 75th Congr. 1st Session. Doc. No. 144. The future of the Great Plains. Message from the President of the United States. 1937. pp. 203.

the situation in the Great Plains apply equally well, at least in principle, to many other parts of the world affected by the problem of erosion and drought.

" The report indicates clearly that the problem of the Great Plains is not merely one of relief of a courageous and energetic people who have been stricken by several years of drought during a period of economic depression. It is much more fundamental than that. Depression and drought have only accentuated a situation which has been long developing. The problem is one of arresting the decline of an agricultural economy not adapted to the climatic conditions because of lack of information and understanding at the time of settlement and of readjusting that economy in the light of later experience and of scientific information now available.

" The settlers of the Plains brought with them agricultural practices developed in the more humid regions from which they came. By historic circumstance the period of settlement was generally one of rainfall above the average, and, although water was known to be scarce, these practices then appeared to be suitable. The long-run experience, however, has disclosed that the rainfall of the area hovers around, and, for considerable periods, falls below the critical point at which it is possible to grow crops by the agricultural methods common to humid regions. A new economy must be developed which is based on the conservation and effective utilization of all the water available, especially that which falls as rain and snow ; an economy which represents generally a more rational adjustment of the organization of agriculture and cropping plans and methods to natural conditions.

" The whole subject of drought on the Great Plains dovetails into the studies made by the National Resources Committee in the larger aspect of public works planning. Previous and current studies of land and water problems have been undertaken on a Nation-wide basis. In this report they have been reworked and applied by the Great Plains Committee in cooperation with other Federal agencies and with State and regional planning agencies as a component part of our desire to develop a program of constructive action for the drought area.

" Whatever program is adopted must be cooperative and will require complementary lines of action by the Federal Government, State Governments, and all the citizens of the region individually. Each has material interests at stake and can no longer afford to defer constructive action ; each has moral responsibility for unwitting contributions to the causes of the present situation ; and especially each has responsibility for undertaking lines of action essential to effectiveness of action by the others.

" The problem is one that can be solved, but the solution will take time. Therefore a policy should be determined, a long-run program formulated, and execution begun without undue delay."

The Report itself is divided into three main parts (six chapters), a Supplement containing four memoranda, and sixteen appendices.

Part 1 gives the general physical characteristics of the area, under the heads of climate, waters (surface or ground), and soils. Part 2 presents all the data which must be considered in connexion with the use and misuse of lands and waters. This

part is divided into four chapters, dealing respectively with (1) population, settlement and land use, (2) undesirable tendencies in land-use and tenure, (3) destructive effects of undesirable tendencies, and (4) attitudes of mind. The list of attitudes of mind in their relation to the problems of land utilization and conservation is particularly interesting.

> " That man conquers nature
> That natural resources are inexhaustible
> That habitual practices are the best
> That what is good for the individual is good for everybody
> That an owner may do with his property as he likes
> That expanding markets will continue indefinitely
> That free competition coordinates industry and agriculture
> That values will increase indefinitely
> That tenancy is a stepping-stone to ownership
> That the factory farm is generally desirable
> That the individual must make his own adjustments."

The following extract is from the introduction to this chapter on attitudes of mind, and the paragraphs dealing with man and Nature.

" Why should there have been destructive tendencies in the use of land and water in the Great Plains ? Chiefly, of course, because of the settlers' lack of understanding concerning the critical differences between the physical conditions of the Great Plains area and those of the area east of the Mississippi whence they had come. Because of this lack of understanding the colonists applied agricultural practices brought from a humid region under conditions for which they eventually proved to be unsuitable. Practices, however, are but outward expressions of controlling attitudes of mind. These settlers also brought with them inherited assumptions which had become ingrained through generations of pioneering experience in a humid region ; assumptions which in large measure account for the practices that are destructive in a sub-humid region.

" These basic attitudes of mind are the directive forces that establish the framework of a new society, govern the activities of the people, and become their standards of judgment. In the course of time they tend to crystallize, fail to take account of new conditions, cease to serve their original purposes, and frequently hinder necessary readjustments.

" Therefore, rehabilitation of a great region in which it has been discovered that economic activities are not properly adjusted to basic and controlling physical conditions is not merely a problem of encouraging better farm practices and desirable engineering works, and revision of such institutions as ownership and tenure. It is also one of revision of some of the less obvious, deep-seated attitudes of mind.

" The basic purposes of economic life do not change. The desire for security, stability, a rising standard of living, increased leisure, self-expression and creative work, remain fairly constant. It is the ideas concerning ways and means by which these objectives may be achieved that must be subject to revision.

"*That man conquers Nature.*—It is an inherent characteristic of pioneering settlement to assume that Nature is something of which to take advantage and to exploit; that Nature can be shaped at will to man's convenience. In a superficial sense this is true; felling of trees will clear land for cultivation, planting of seed will yield crops, and applications of water where natural precipitation is low will increase yields. However, in a deeper sense modern science has disclosed that fundamentally Nature is inflexible and demands conformity. On this point Aldo Leopold has well said: 'Civilization is not . . . the enslavement of a stable and constant earth. It is a state of *mutual interdependent cooperation* between human animals, other animals, plants, and the soils, which may be disrupted at any moment by the failure of any of them. Land despoliation has evicted nations, and can on occasion do it again . . It thus becomes a matter of some importance, at least to ourselves, that our dominion, once gained, be self-perpetuating, rather than self-destructive.' [The conservation ethic. *J. For.* 31. 635. 1933.] We know now, for instance, that it is essential to adjust agricultural economy on the Plains to periods of deficient rather than of abundant rainfall, and to the destructive influence of wind blowing over dry loose soil rather than primarily to a temporary high price for wheat or beef; that it is our ways, not Nature's, which can be changed."

The lines of action suggested include Federal action, State action, local action and readjustments in farm organization and practices. The need for coordinated action is urgent; as an example of the rapidity with which excessive areas are given over to arable farming, it is noted that the 1936 seeding of wheat in the ten Great Plains State was the largest on record, and that the area included many tracts unsuitable for arable farming. The Great Plains Committee therefore considers that there is ample justification for setting up some continuing territorial agency intended to promote the required readjustments. An agency set up for this purpose should not displace existing agencies, of which there are many, "nor should it assume any administrative control of the operations which those bodies normally carry on. Its proper field should be that of continuing study of the Great Plains problem as a whole, and of endeavouring, by consultation, education, persuasion, and guidance, to integrate the efforts of all forces concerned toward a common end.

"The agency should be given authority to call on the various Federal agencies functioning in the Great Plains for such information as may be required to make field coordination effective. Any department of the Federal Government should be afforded the opportunity of designating a liaison officer to represent it in its relations with the proposed agency.

"Among the duties of the suggested agency might well be:

(a) To aid in effecting the closest possible coordination between Federal agencies and State and local agencies working toward the economic reorganization of the Great Plains;

(b) To encourage all varieties of research of special interest to the Great Plains area, to collate and analyze available data relating to the area, and to procure directly such necessary supplemental data as existing agencies feel that they are not in a position to procure;

(c) To coordinate the execution of the recommended program of land use mapping to the end that it shall be of the maximum utility to the various agencies whose work requires such mapping ;

(d) To follow educational efforts throughout the area which look toward the conservation of soil and water resources, to the end that such efforts may be made most effective ;

(e) To report annually, with recommendations as to Federal legislation bearing on the Great Plains, after appropriate consultation with administrative departments ;

(f) To recommend to States and local political subdivisions such legislation as is deemed advisable ;

(g) To perform such other functions as may be assigned to it from time to time."

" The economic drift in the Great Plains for years past has been steadily downward. If economic deterioration of the Great Plains Region, recently heightened as a result of the depression and drought, is to be stopped, it will be only because the Nation takes the situation in hand promptly, emphatically, and competently."

The Great Plains Committee had the following membership :

Harlan H. Barrows. Professor of Geography, University of Chicago ; Member, Water Resources Committee, National Resources Committee

H. H. Bennett. Chief, Soil Conservation Service, Department of Agriculture

L. C. Gray. Assistant Administrator, Resettlement Administration

F. C. Harrington. Assistant Administrator, Works Progress Administration

Richard C. Moore. Colonel, Corps of Engineers, U.S.A., Division Engineer, Missouri River Division

John C. Page. Acting Commissioner, Bureau of Reclamation, Department of the Interior

Harlow S. Person. Consulting Economist, Rural Electrification Administration

Morris L. Cooke. Administrator, Rural Electrification Administration (Chairman.)

SOIL CONSERVATION SERVICE : RESEARCH PROGRAMME

[Reviewer : R. O. Whyte]

A special number of the journal, *Soil Conservation*, is devoted to the research programme of the Soil Conservation Service of the United States Department of Agriculture. In formulating the principles of the new type of agriculture which must necessarily be developed as soon as possible in all countries affected by the erosion problem, the methods to be recommended must be based upon scientific data from specially planned experiments. The American conservationist is in an advanced position in this respect, as he already has at his disposal ten years' results from a dozen

soil erosion experiment stations, as well as the varied information collected by the State experiment stations during the past 50 years.

According to Dr. W. C. Lowdermilk, land-use is conditioned essentially by three major factors, namely, (a) needs of plant and animal products, (b) soil productivity, and (c) integrity of the soil resource. All factors are interrelated, but safeguarding the physical integrity of the resource with its direct and indirect influences becomes a primary requisite in long-range conservation of land resources. The outlook on the function of research as related to the American conservation programme may be stated as follows: (Quoted from article by Dr. Lowdermilk, *Soil Conservation*, 3. 204-8. 1938).

"Research in soil conservation involving causes and control of erosion must begin with the soil resource, including the normal processes of its formation and removal and its interrelations with plant and water resources. It must, thereupon, explore the nature, causes, extent and effects of soil and water wastage under necessary agricultural pursuits. It must determine and test fundamental, practical and economically feasible means of conserving the resource by preventing undue wastage and by restoration of these resources incident to needful and sustained land use. It must bring to bear upon the problems involved several fields of science and practice and call into effective co-operation the agencies concerned with these special fields; it must develop in co-operation with State agricultural experiment stations a forward-looking programme of needed basic and applied research by States and problem areas. It must plan and carry out, in co-operation with State agricultural experiment stations and other appropriate scientific and technical agencies, essential projects of basic and applied research. It must take part in fitting the findings of research to the land in accord with its needs and adaptabilities on operations projects as proving grounds, in co-operation with field and technical organizations. It must further provide, in co-operation with State agencies, for adequate basic and applied research on the effects of land use on water resources, stream flow, and flood flows as influenced by rates and amounts of storm run-off, by detention storage, and by the accumulation of erosional debris. It must determine, in collaboration with appropriate agencies, the economics of erosion and of its control from the viewpoint of the farmer as well as from that of the community and the public.

"In fulfilling these functions, research must serve the present and future needs of farmers and of land-use agencies and contribute to the planning for sustained land use by furnishing the specialists of the Soil Conservation Service engaged in work on the land, and other agencies, tested and reliable information on, as well as criteria for, measures and practices of soil and water conservation. The research function embodies the role of the prophet."

As has been described in *Herb. Publ. Ser. Bull.* 25 (pp. 136-42), the Division of Research is organized into six sections, dealing with:

1. Investigations of the principles involved in soil and moisture conservation and methods for their practical application on agricultural lands.
2. Watershed investigations of the effect of land-use practices on run-off in relation to the methods of control of erosion and floods.

3. Investigations of sedimentation resulting from erosion.
4. Investigations of geographic and climatic factors relating to erosion.
5. Investigations of erosion-resisting plants of economic value.
6. Co-operative investigations of economics of soil erosion and erosion control.

A brief account of some current results of the research under these heads is given in a group of specialist articles in the same number of *Soil Conservation* :

A. E. Brandt : Size and shape of control plots for run-off studies
G. W. Musgrave : Field research offers significant new findings
C. E. Ramser : Hydrologic investigations on selected watersheds
G. C. Dobson : Relation of sedimentation studies to a flood-control programme
W. J. Roth and A. N. Garin : Economic implications of a soil and water conservation programme
C. W. Thornthwaite : Recent achievements of the section of Climatic and Physiographic Research
S. B. Detwiler : The soil-saving persimmon
M. P. Connaughton : Preliminary notes on reservoir studies in the Great Plains States.

HEADWATERS CONTROL AND USE

[Reviewer : R. O. Whyte]

The problem of the correct control and use of the headwaters of rivers in all countries necessarily depends on a great many factors, all of which play their part when properly manipulated in conserving soil and run-off in all parts of the watershed and in protecting the valley lands from the dangers of flood and the rivers and harbours from siltation. An introduction to these numerous factors may be readily obtained from a study of the papers presented at the Upstream Engineering Conference held in Washington, D.C., on September 22 and 23, 1936, which have been published in a special volume, entitled " Headwaters control and use ", with the subtitle of " A summary of fundamental principles and their application in the conservation and utilization of waters and soils throughout headwater areas."*

It is first necessary to consider water behaviour and land-water relationships. A proper understanding of the basic principles of water behaviour depends upon a knowledge of hydrology, the behaviour of water as it occurs in the atmosphere, on the surface of the ground, and underground. The generalized picture of the

*United States, Department of Agriculture, Soil Conservation Service. Headwaters control and use. A summary of fundamental principles and their application in the conservation and utilization of waters and soils throughout headwater areas. [Papers presented at the Upstream Engineering Conference held in Washington, D.C., September 22 and 23, 1936.] 26 × 20. 270 pls. Washington : S.C.S. and Forest Service, U.S. Department of Agriculture, with the co-operation of Rural Electrification Administration, 1937. Price 60 cents.

movements of water as it relates to the earth is called the hydrologic cycle, the major elements of which may be elaborated as follows :

Atmospheric moisture
Precipitation
Precipitation not reaching the ground
Precipitation reaching the ground
    Infiltration
    Surface run-off
    Ground evaporation
Evaporation
    Evaporation from water surfaces
    Evaporation from the ground
    Evaporation from vegetation
Transpiration

Although all the factors which make up this cycle are known, little is understood about their interrelationships, which are so essential to a scientific approach to many problems of land and of water use. The subject of upstream engineering is largely a hypothetical realm ; it is necessary to have many more rain gauges, stream gauges, snow surveys, evaporation fans, transpiration and infiltration measurements. The lack of basic hydrologic data has had serious consequences in loss of life, bad design, failures of water undertakings, etc.

Two other important factors to be considered in upstream engineering may be mentioned. The first is the relationship between land-conservation measures and water-conservation measures. No matter how valuable soil conservation measures, check dams, vegetative cover, reforestation, or improved agricultural practices may be from a land-conservation standpoint, it does not necessarily follow that these same measures may be justifiable from a water-conservation standpoint. The relation between the two depends upon knowledge of the hydrologic cycle. The second element is that of the economics of effective upstream engineering.

From a general consideration of the basic hydrologic principles we come to the particular aspect of prime importance to the soil conservationist, the control of surface run-off. In a brief outline of the manner in which surface run-off takes place, consideration is given to the following aspects : infiltration theory of surface run-off, initial detention or depression storage, and overland flow. The variables involved in surface run-off are :

1. Rain intensity during rainfall excess
2. Infiltration capacity
3. Volume of depression storage
4. Rainfall excess duration
5. Length of overland flow
6. Slope of surface
7. Surface roughness coefficient.

Any method of modification of the surface phase of the hydrologic cycle operates through changing one or more of the seven variables listed above. Rain intensity and duration cannot be changed. Such changes in these variables as are involved in terracing or are related to the controlling effect of sod on run-off are considered.

It is now well established that a good sod or grass cover is the most effective natural means of controlling surface run-off and preventing erosion. It would appear that the beneficial effects of a dense grass cover in reducing run-off intensity and volume result mainly from :

1. An increase in surface detention by capillary storage in wedge-shaped spaces between grass leaves or leaves and stems.
2. Better sustained and probably higher infiltration capacity and prevention of closing of openings in the soil surface by inwashing of fine material, as described by Lowdermilk [Influence of forest litter on run-off, percolation and erosion. *J. For.* 474-91. April, 1930.]
3. A different type of overland flow from that prevailing on other soil surfaces. This may be designated " subdivided flow."

The fact that any method which increases the infiltration will also increase the loss of nutrient material from the soil by leaching is regarded as an incidental and unavoidable evil. The value of conservation measures designed to increase infiltration and thereby to add to and raise the ground water-table, particularly as a plant reserve during droughts, is obvious.

From the past fragmentary and random experiences in soil conservation and from results of the brief period of research carried out at the Soil Conservation Experiment Stations in the United States, tentative rules for agricultural conservation have been drawn up. Within the Soil Conservation Service, the approach has been on a regional basis in order that such dominant factors as climate, physiology, soil types, natural vegetal cover, established crops and social adjustments may be included. The plans of the Soil Conservation Service embody a programme of research which is intended ultimately to make possible, on an areal basis, the quantitative analysis of the many factors known to influence run-off.

Vegetation has an important influence on land-water relationships. The "short grasses " are used to illustrate the interaction of soil and vegetation. " Perhaps nowhere in the world is the interaction between soil and plants so nicely maintained as in the short-grass areas of plains vegetation, where the depth of the carbonate layer delimits the level to which the absorption of water and nutrients usually takes place. It is in the surface zone of the marvelously efficient root systems of short grasses that all of the available moisture is appropriated each year, and there is virtually no penetration of surface water to deeper levels. The gross amount of average annual precipitation or its seasonal distribution are but poor indicators of the amount of water available to given plants in a given soil of the short-grass region." Scientific agriculture attempts to maintain the natural harmony between vegetation and soil, or to improve upon it. The two specialized aspects, scientific forestry and grazing, seek to do the same thing. If harmony is preserved by science combined

with public control where necessary, the indirect benefits will be many—flood costs will be lower, silting of reservoirs diminished, and water can be used for irrigation or industry.

Following the opening discussion of the fundamental aspects of upstream egineering, the next contributors to the symposium are concerned with the conservation practices based on the land-water relationships, as they affect the management and use of forest and range lands, agricultural lands, farm woods and pastures. For example, the close relationship is indicated between mismanagement or maladjustments in the utilization of agricultural lands, the progressive decline of the ground water-table, depletion of the soil, increasing risk of flood, and silting ; the techniques which have been developed for regulating the behaviour of rain water after it has fallen on the land are outlined.

In the development of a conservation economy, a number of special aspects arise, e.g. effectiveness of dams, farm ponds for water supply and flood control, highway construction and water conservation, malaria control, water spreading over absorptive areas for storage underground, artificial methods of ground-water recharge, ground water for drought relief, and zoning as a technique for water conservation.

A special section of the symposium is devoted to a study of the place of the wildlife " crop " in the development of a proper technique adapted to the conservation of water and soil.

Finally, the whole problem with its many ramifications is considered in larger perspective, for example, from the engineering and human value points of view.

CONFERENCES

Conference on Pedology and Plant Physiology, Saratov, U.S.S.R.

On January 24 to 30, 1937, a conference was held at the State University, Saratov, on the problems of soil science and the physiology of plants cultivated in the arid south-east region of Soviet Russia. Over 500 persons representing 74 scientific institutions in the Union took part in this Conference (an account by K. S. Semakin in *Sov. Bot.* 1937. No. 3. 119-20.).

Plenary Meetings. Apart from four reports dealing with questions of soil science a paper was read by Professor N. A. Maximov on "Salt resistance of cultivated plants under irrigation."

Sectional Meetings. The work of the Conference was divided into four sections dealing with the following subjects :

Genesis of soil
Melioration of soil in the south-east
Soil fertility
Plant physiology.

The following papers were read to the section of plant physiology. It is hoped that abstracts of the majority of these will be included in a future issue of *Herbage Abstracts*, and that a review may be produced in *Herbage Reviews*.

N. A. Maximov. The progress of physiological processes in plants under drought and irrigation.
P. A. Henkel. The problem of pre-sowing hardening of plants to drought.
A. S. Kružilic. The root system of field crops of the south-east under dry farming and irrigation.
N. V. Guščin. The salt resistance of cultivated plants and its causal factors.
A. M. Alekseev. The effect of edaphic drought on the growth of leaves in wheat.
I. P. Galjčenko. Physiological indicators of water requirement of plants as a basis for elaborating field schemes.
N. D. Leonov. Photosynthesis at small concentrations of CO_2.
T. A. Krasnoseljskaja. Physiology of the apple tree in relation to edaphic conditions.
A. A. Kuzjmenko. Moisture of soil, yield and chemical composition of the tobacco plant.
S. V. Tageeva. The physiological characteristics of artificial rain.
O. V. Trubeckova. Nitrogenous exchange in plants under wilting.
V. A. Čižov. The effect of soil moisture on utilization of nitrogenous fertilizers.
I. G. Potapov. The transport of nutrient substances in the plant.
A. M. Babič. Critical moisture of soil in the application of various forms of mineral fertilizers.
A. D. Smirnova. Critical periods and physiological processes in sunflower under wilting.
O. V. Zalenskiĭ. Determination of the amount of water evaporated by wheat plants.
Manuĭlov. Diagnosis of perishing winter sowings in the Kuĭbyšev (Samara) province in 1936.
P. K. Ivanov. Hardening of seed as a means of increasing yield.
K. S. Semakin. The growth rate as an indicator of the resistance of plants to drought. [*Herb. Abstr.* 8. No. 2. 1938.]

ŠČERBAKOV. The effect of potassium on the water-holding capacity of plant tissues.
EVTUŠENKO. Peculiarities of tobacco plants in connexion with drought.
VJUNOV. Chlorosis of fruit trees.
ALTERGON. Physiological and biochemical bases of the resistance of plants to heat.
A. V. LAVROV. New methods of investigation of soil for physiological purposes.

In conclusion, the following items were suggested by the Conference for immediate investigation :

(1) Supplementary nutrition of plants in the South-East.
(2) Transport of N, P and K into the plants at a soil moisture below 150 per cent hygroscopicity.
(3) The nature of pre-sowing hardening of plants to drought and frost.
(4) The possibility of hardening plants to salts.

The proceedings of the Conference are to be published by the State University Saratov.—M.A.O.

Argentine Society for the study of Natural Science

The first Conference of this Society took place at Tucumán in July, 1916, the second in the town of Mendoza, April 3-11, 1937. A brief report on papers read to the Applied Science Section is given in *Rev. Argent. Agron.* 4. 134-6. 1937. They include the following :—

CLOS, E. C. [Types of ground-nut (*Arachis hypogaea*) cultivated in Argentina and their geographical distribution in that country.] Fifteen cultural varieties were distinguished, morphologically distinct, characterized by habit, the quantity of seeds per fruit, the colour of the tegument, and the size of fruit and seeds.

PRADO, L. de, and DASTUGUE, H. BASSO. [Study of *Astragalus chilensis*, a poisonous plant of the Neuquén.]

MUTINELLI, A. [An interesting indigenous legume in Misiones.]

PARODI, L. R., and PASTORE, Ada J. [Cultivated plants of economic importance represented in the indigenous flora of Argentina.] Autochthonous material worthy of improvement was indicated, the genera listed including *Oryza*, *Hordeum*, *Phaseolus* and *Daucus*.

GUIÑAZU, R. [Projected creation of natural reserves in the province of San Luis.]

BURKART, A. [Contribution to phytotechnical work on lucerne.] The author's experience in the improvement of lucerne has indicated the frequency with which natural hybridization takes place and the possibility of obtaining in the F_1 generation hybrids of greater productivity.—G.M.R.

Norwegian Section of N.J.F.

The Norwegian Section of the Nordiske Jordbruksforskeres Förening (Association of Scandinavian Agricultural Investigators) held its annual meeting during agricultural week at Oslo on March 1st (*Tidsskr. norske Landbr.* 45. 159. 1938). An address on Norwegian experience of the A.I.V. method of ensilage was given by L. S. Spildo.

Professor Kosmo was re-elected president and Professor Ødelien vice-president for 1938-39.—R.P.J.

Central Fodder and Grazing Committee, India

The general question of grazing was discussed by the Animal Husbandry Wing of the Board of Agriculture and Animal Husbandry at its meeting at Madras on December 14 to 16, 1936. Its recommendations were accepted by the Cattle Conference held at Simla in May, 1936, and the creation of the Central Fodder and Grazing Committee followed. Resolution No. 1 of the Cattle Conference was as follows :

" With a view to securing systematic and progressive improvements in grazing and grassland areas and the conversion of wasteland into useful grazing, wherever that is possible on an economic basis, the Conference recommends (i) that in all the provinces Standing Fodder and Grazing Committees should be established on the lines recommended by the Board of Agriculture and Animal Husbandry, and (ii) that a Central Committee to co-ordinate grassland and fodder research and the dissemination of information should be set up by the Imperial Council of Agricultural Research."

Only one provincial committee has so far been constituted, in the United Provinces, while committees in other provinces are still in the process of formation. The second part of the resolution of the Cattle Conference constitutes the terms of reference of the Central Committee which met for the first time under the chairmanship of Sir Bryce Burt, Vice-Chairman of the Imperial Council of Agricultural Research, the members being the Animal Husbandry Expert, the Agricultural Expert, and representatives from other Departments such as Forest, Agriculture, Veterinary and Remounts and Farms of the Army Headquarters. As this was the first meeting of the Committee the agenda was provisional. The following were some of the items discussed :

(1) Measures required to obtain complete information regarding the fodder and grazing situation in India. Bibliographies are to be prepared on (i) grasses and grasslands and fodder trees, and (ii) the cultivated fodders ; also on erosion in India as connected with the grazing problem and on work in India on feeding tests of all cattle food. An estimate of the cultivated fodders might also be prepared.

(2) Measures to be taken for experiments in improvement of grasslands.

(3) Consideration of the bearing of the reports of Sir John Russell and Dr. Wright on the general policy with regard to the improvement of fodder and grazing and also in connexion with any particular schemes mentioned in these reports. It was decided, after consideration of the chapter of Dr. Wright's report stressing the need for much greater attention to the growing of special fodder crops, that the following should be commended to the provincial committees : (i) breeding of quick growing fodders, (ii) possibility of fodder growing in rotation and cutting in the young stage, and (iii) the importance of carrying out investigations on the fodder values of pulses.

(4) Consideration of any written or verbal reports from members of the Committee who attended the International Grassland Congress at Aberystwyth in 1937.

(5) Consideration of how best liaison could be effected with the Imperial Bureau of Pastures and Forage Crops, Aberystwyth.

(6) Consideration of how far the improvement of grasslands is likely to be feasible through (i) reseeding with indigenous varieties of grasses, (ii) reseeding with imported grasses, (iii) reseeding with indigenous or imported leguminous plants.

(7) Consideration of how far an attempt should be made to breed better strains of indigenous wild fodder grasses.

(8) On the general subject of land utilization, it was proposed to discuss the possibility of clearing suitable areas in pole forests of little value and laying them down to grass or fodder crops which could be cut and preserved as molasses-ensilage for use later in the season when the natural grazing begins to fail.

(9) It is proposed that the Committee should discuss in all its bearings the possibilities of taking steps to control the spread of contagious diseases among forest herds.

(10) Grazing fees.

(11) Grazing facilities for goats in India and matters cognate thereto. The Committee recorded the opinion that it was impossible to admit goats into any kind of forest areas without risk of serious damage. They could best be fed on cultivated fodders and by suitable loppings.

(12) Liaison of the Central and the provincial committees.

(13) Survey of grasslands in the Provinces.

ANNOTATIONS

GREAT BRITAIN (410)

The Plant Hormone Committee

As the outcome of a meeting held at the Royal Botanic Gardens, Kew, on November 6 (see *Nature* 141. 88. 1938), a Committee, to be known as " The Plant Hormone Committee," has been formed with the following membership : Mr. F. P. Knight (Knap Hill Nursery Co.), Dr. C. R. Metcalfe (Kew, convenor and secretary), Mr. F. O. Mosely (Lowe and Shawyer, Ltd.), Prof. R. H. Stoughton (University of Reading), Mr. W. G. Templeman (Imperial Chemical Industries, Ltd.), and Dr. M. A. H. Tincker (Royal Horticultural Society). The terms of reference are " to consider the practical applications of ' phytohormones ' in relation to plant cultivation." The committee is at present engaged in compiling a list of species of which cuttings cannot easily be struck even by experienced propagators, in the hope that by intensive experimentation, methods for propagating them successfully may be discovered. Further information about the committee may be obtained from the Secretary.—*Nature*, Vol. 141. No. 3568. pp. 508-9. 1938.

GERMANY (43)

Grassland Institute of the Livestock Experimental and Research Station, Kraftborn (formerly Tschechnitz)

The name of the parish in which the Station is situated was changed from Tschechnitz to Kraftborn in 1936, and the Station will accordingly be known as the Kraftborn Station in future. The 1935-37 report of the Grassland Institute, one of the three comprising the Station, is presented by the Director, Prof. Tiemann, in *Landw. Jb.* 85. 335-47. 1938. The reorganization and re-establishment of the Institute in 1935-36 have removed certain difficulties experienced since 1932 and have enabled a longer view to be taken in the planning of its activities. The greater part of the Institute's work was of an advisory nature. Open days for farmers and others, held in 1935 and 1936, are described ; much interest was evinced in the frame-drying of hay and in ensilage technique.

Plant breeding. This is to be organized on a broader scale in future. In the meantime the work on *Trifolium incarnatum*, *Medicago*, *Agrostis*, *Festuca pratensis* and *Lolium perenne* has been continued, tests of bred strains of crimson clover for winter hardiness have been made in hill country, and work on some other forage crop plants has been taken up. Varietal tests are concerned with the Station's own bred strains and (on behalf of the Reichsnährstand) with lupins, vetch, clovers and grasses.

Pasture experiments. An experiment in progress since 1932 at Kraftborn (east continental lowland climate) and at Wernersdorf (hill country), designed to test the value of applying nitrogenous fertilizers at different times, was terminated in 1936. Results in the hill country showed that doses of 80 to 100 kg. N per hectare (given an adequate supply also of humus, CaO, K and P) are decisive for yield. In such country the doses of nitrogenous fertilizer may be distributed over the whole growth period, and it is advisable so to arrange them that advantage may be taken also of rainfall in August and September. In the lowlands, on the other hand, yield was considerably lower, for which the low rainfall is held principally responsible. Here the application of N should be limited to the more rainy parts of the year. An experiment in the application of farmyard manure combined with watering, described in a previous report [see *Herb. Rev.* 4. 159. 1936], was continued. The yield of the manured and watered paddock was 40 per cent higher than that of the other two paddocks (manured and unwatered, unmanured and unwatered). The manured but unwatered plot did not in 1935 give an appreciably better yield than the control paddock, but in 1936 it gave the highest yield of all, which was probably due to good rainfall. Of the total yield of starch equivalents for the three years, however the manured and watered paddock gave the highest proportion, its yield being 1,217.06 kg. more than that of the manured but not watered paddock. In 1935 an experiment was laid down to test the value of pure sowings of *Festuca rubra*, *Poa pratensis*, *Agrostis*, *Lolium perenne* and *Festuca pratensis* as grazing for dairy cows, with special reference to milk production and the fat content of the milk, in comparison with sowings of mixtures. Results are not yet reported.

Meadows. Experiments in various methods of improvement have shown their efficacy to be as follows: application of commercial fertilizers<the same treatment plus scratching and seeding<ploughing up with or three years' use for arable crops and resowing. Grazing by cattle and sheep or sheep-folding after the first cut produced good results. The experiments continue. A comparison of the nutritive value of meadow cuts taken at different times is in progress. In 1937 a trial was laid down to test the effect of liquid manure applied in the autumn, winter and early spring respectively, on open, frozen, and snow-covered ground, in comparison with the effect of artificial fertilizers.

Catch crops. Investigations include the comparison of a large number of plants for yield of starch equivalents when grown *after* a winter crop; the testing of maize, sweet lupins and other plants for their value as supports of vetch-pea mixtures; and a study of the extent to which catch crops reduce the yield of ensuing crops

through excessive utilization of water. Results and conclusions have been embodied in Tiemann's book " Catch crop cultivation," published by the Reichsnährstand.

Variety trials.....Maize, field beans, pulse, clover-grass and lucerne-grass mixtures and fodder beet were concerned.

Ensilage studies, a special feature of the work at Kraftborn, have been continued.

The Animal Nutrition Institute of the Kraftborn Station (report for 1935-37 presented by Prof. K. Richter, *Landw. Jb.* 85. 348-64. 1938) included in its activities the testing of a large number of forage crops for their nutritive value and effect upon milk production and dairy produce. These crops included *Vicia sativa* (seed, untreated and disembittered respectively) [see *Herb. Abstr.* 7. 310 (Richter and Herbst, and Richter) 1937] ; the fodder mallow, green, chopped ; Sudan grass ; sugar beet tops ; green lucerne. Various types of silage were similarly tested.—G.M.R.

USSR (47)

Institute of Biochemistry of the USSR Academy of Science

Some results of the research in progress at this Institute for 1935-37 are given by D. M. Mihlin [Izvestija Akad. Nauk SSSR. Biolog. ser. 1937, No. 5, 1453-67. (English summary)]. The investigations were chiefly concerned with the interrelation of enzymes with some other catalytic substances and with the reversibility of enzymatic activity.

In research with inverthasis it was established that for every plant and even every variety there is a definite relation between synthesizing and hydrolyzing activity. Although this relation may vary with environment, it can yet be regarded as a biochemical character of a variety. Varietal differences occur in catalase activity between genetically different types of barley. Higher enzymatic activity was found to be recessive.

In work with living cells and enzymatic preparations, the equilibrium in reversible enzymatic reactions was found to depend upon the adsorption of enzymes and the condition of the colloids. Through a preliminary activation, glucose was synthetically obtained from fresh preparations of the mammary glands. Glycolytic and oxidative metabolism of carbohydrates in living cells is connected with reversible reactions of phosphorylation and dephosphorylation. The oxidative process is probably of importance in the biochemical changes of glucose.—M.A.O.

SWEDEN (485)

Swedish Grassland and Bog Cultivation Association

Svenska Vall-och Mosskulturföreningen (the Swedish Grassland and Bog Cultivation Association) is the new association resulting from the amalgamation of the

Swedish Grassland Society and the Swedish Society for the cultivation of Peat Land. (*Tidsskr. norske Landbr.* 45. 159. 1938.)

The object of the Association is to work for a rationally conducted pasture, meadow and bog cultivation by means of experiments, practical scientific investigations, collection of practical experiences, courses of instruction, etc.

The new association will have its headquarters at the institution of the Swedish Grassland Society in Ultuna.—R.P.J.

DENMARK (489)

State Department for Research in Plant Pathology

The Department was established as a branch of the State Committee on Research in Plant Culture on April 1st, 1913. A description is given of the botanical and zoological sections, the testing of disinfectants, the information section and chemical control during the period 1913-38 in *Tidsskr. Planteavl.* 43. 159-175. 1938.

In 1938 a Patho-technical Committee was appointed by the State Plant Breeding Committee to promote collaboration between the various groups concerned with disinfectants.—R.P.J.

SWITZERAND (494)

Institute of Agricultural Chemistry, Liebefeld, Bern

A report on the Institute's activities in 1936 is presented by the Director, Dr. E. Truninger, in *Landw. Jb. Schweiz*, 51. 935-60. 1937.

The following manurial trials are of interest. (1) The potassium content of herbage from land constantly dressed with liquid manure is too high. Liming furnishes a means of reducing this as well as of improving the chemical and physical condition of the soil, and a pot trial was conducted with a view to ascertaining suitable forms and amounts of lime for the purpose. The material was *Trifolium pratense*, *Sinapis*, *Dactylis glomerata*, *Medicago*, and a cocksfoot-red clover mixture. Results are reported. (2) The fourth year's continuation of the experiment in applying liquid manure and farmyard manure to hay land at different times confirmed previous findings that the best results are obtained from liquid manure by applying in the winter to land free of snow. No clear conclusions could be drawn from a comparison of applying farmyard manure in November, February (on frozen ground), and in March respectively. The experiment continues for another year. (3) A long-duration experiment for the comparison of one-sided and rational manurial treatment has been in progress for seven years. The effect upon the floristic and chemical

composition of the herbage is to be studied. Conclusions are not yet available. (4) The comparison of three forms of CaO in relation to their effect upon the calcium content of herbage has continued for a sixth year, and is to proceed further. Under the conditions of the trial the application of finely ground calcium carbonate resulted in perceptibly increased yield ; the effect of gypsum was less ; and calcium saltpetre took an intermediate position for efficacy. Other manurial trials still in progress include a new one to test the effect of adding different quantities of water to the same quantity of liquid manure (on hay land) ; trials of phosphates on alpine pastures at altitudes of 860 and 1,020 m. ; and small plot manurial experiments with grasses for demonstrational and analytical purposes.

The study of the conditions producing pica in cattle continues, and a report is to be published in due course. In addition feeding trials have been conducted, concerned respectively with (a) alpine hay poor in phosphoric acid, fed to young cattle ; (b) herbage with very high potassium content, fed to dairy cows.

The systematic botanical and chemical study of typical meadow stands, begun in 1935, was continued.—G.M.R.

AUSTRALIA (94)

Ransom Mortlock Laboratory

" An important step in the campaign against soil erosion has been taken by the opening of the Ransom Mortlock Laboratory at the Waite Research Institute, The late Ransom Mortlock was a descendant of a pioneer pastoral family which has made a benefaction for the erection of a building and the establishing of a fund for research into erosion and plant regeneration in pastoral districts laid waste by drought, overstocking and rabbits. Numerous plants have already been collected from various parts of Australia to test their fodder and soil-binding merits."—Times, May 2, 1938.

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